How to Calculate Prayer Times?

PRAYER TIMES

A hadîth-i sherîf quoted in the books **Muqaddimet-us-salât, at-Tefsîr-al-Mazharî** and **al-Halabî al-kebîr** states: **"Jabrâîl 'alaihissalâm'** (and I performed [the prayer termed] namâz [or salât] together, and Jabrâîl 'alaihis-salâm') **conducted the prayer as the imâm for two of us, by the side of the door of Ka'ba, for two days running. We two performed the morning prayer as the fajr** (morning twilight) **dawned; the early afternoon prayer as the Sun departed from meridian; the late afternoon prayer when the shadow of an object equalled its midday shadow increased by the length of the object; the evening prayer as the Sun set** [its upper limb disappeared]**; and the night prayer when the evening twilight darkened. The second day, we performed the morning prayer when the morning twilight matured; the early afternoon prayer when the shadow of an object increased again by the length of the object; the late afternoon prayer immediately thereafter; the evening prayer at the prescribed time of breaking fast; and the night prayer at the end of the first third of the night. Then he said 'O Muhammad, these are the times of prayers for you and the prophets before you. Let your Ummat perform each of these five prayers between the two times at which we performed each'."** This event took place on the fourteenth of July, one day after the Mi'râj, and two years before the Hegira. Ka'ba was 12.24 metres tall, the solar declination was 21 degrees and 36 minutes, and Ka'ba's latitudinal location was twenty-one degrees and twenty-six minutes. Hence its midday (shortest) shadow (fayi zawâl) was 3.56 cm. Thereby performing prayers (salât) five times a day became a commandment. This hadîth-i sherîf clarifies that the number of (daily) prayers is five.

It is fard (obligatory duty) for all Muslims, male and female alike, who are 'âqil and bâligh, that is, who are discreet and have reached the age of puberty or, in other words, the age for marriage, to perform the five daily prayers called salât (or namâz) within their correct times. If a salât is performed before the beginning of the time prescribed (by Islam) for it, it will not be sahîh (valid). In fact, it is a grave sin to do so. As it is fard to perform a salât in its correct time for it to be valid, it is also fard (or farz) to know for certain and without any feeling of doubt that you have performed it in its correct time. A hadîth-i sherîf in the book **Terghîb-us-salât** states: **"There is a beginning and an end of the time of each salât."** The early time for a prayer at a certain location is the time when the true Sun reaches a certain altitude with reference to the apparent horizon of that location.

The Earth on which we live rotates around its axis in space. Its axis is an imaginary straight line going through the Earth's center and intersecting the Earth's surface at two symmetrical points. These two points are termed the (terrestrial) Poles. The sphere on whose inner surface the Sun and the stars are imagined to be moving is termed the **celestial sphere**. Because the Earth revolves around the Sun, we get the impression as if the Sun were moving, although it is not the case. When we look around, the Earth and the sky appear to meet on the curved line of a tremendous circle. This circle is termed line of **apparent horizon**. In the morning the Sun rises on the eastern side of this horizon. It moves up towards the middle of the sky. Culminating at noontime, it begins to move down. Finally, it sets at a point on the western side of the line of apparent horizon. The highest point it reaches from the horizon is the **time of noon** (zawâl). At this time, the Sun's altitude from the (line of apparent horizon) is termed the **meridian altitude** ('ghâya irtifâ' = 'culmination'). A person (supposed to be) gazing at the sky is called **observer** (râsid). The Earth's radius intersecting the Earth's surface at a point exactly under the observer's feet is at the same time the observer's **plumb-line**. The observer is at point M, which is some distance above the Earth's surface. ME is the observer's plumb-line. Planes perpendicular to this plumb-line are termed the observer's **horizons**.

There are six planes of horizon: (Please read the explanations below fig.1-A!) 1– The plane MF, termed (mathematical horizon), which goes through the observer's feet. 2– The plane BN, termed (tangential horizon), which is tangent to the Earth's surface. 3– The plane LK, termed (mer'î=[visible, observed] horizon), whereby the (line of apparent horizon) surrounding the observer, (i.e., the circle marked LK,) is determined. 4– The plane, termed (true horizon), which goes through the Earth's centre. 5– The plane P, termed (shar'î horizon), which coexists with the apparent horizon belonging to the highest point of the observer's location; the circle q around which this plane intersects the Earth's surface is termed (line of shar'î horizon). These five planes are parallel to one another. 6–The plane of tangential horizon passing through the observer's feet is termed the **surface** (sathî) **horizon**. The higher the observer's location, the wider and the farther away from the tangential horizon is the apparent horizon, and the closer is it to the true horizon. For this reason, a city's apparent prayer times may vary, depending on the altitudes of its various parts. On the other hand, there is only one prayer time for each prayer (namâz). Therefore, apparent horizons cannot be used for the determination of prayer times. Shar'î altitudes are employed because they are based on shar'î horizons, which in turn will not admit of any further changes contingent to increase of height. Each prayer (namâz) has three different prayer times for three of the six different horizons of every location: True; apparent (zâhirî); and shar'î times. Muslims who (live at such a location as they possess the conditions wherein they can) see the Sun and the horizon perform (each prayer of) namâz at its shar'î time, which is when the Sun's altitude from the shar'î horizon attains its position which Islam ascribes to the prayer time. Muslims who do not see them are to perform their prayers of namâz at their shar'î times determined by calculation. However, altitudes based on shar'î horizons are longer than apparent altitudes based on apparent horizons. These horizons cannot be used because prayer times are after noon. There are mathematical as well as mer'î (observed) times for each of the (daily) three prayers of namâz. Mathematical (riyâdî) times are determined by calculation based on the Sun's altitude. Mer'î times are obtained by adding eight (8) minutes and twenty (20) seconds to mathematical times, because it takes the Sun's rays eight minutes and twenty seconds to come to the Earth. Or it is determined by observing that the Sun has reached a certain altitude. Namâz is not performed at mathematical or true times. These times help to determine the mer'î times. Altitudes relating to sunrise and sunset horizons are zero. Altitudinal degrees with respect to apparent horizon begin as the Sun rises, before noon; and after true horizon, after noon. Shar'î horizon is before true horizon, before noon; and it follows true horizon, after noon. The Sun's altitude at the time of fajr-isâdiq is −19° according to all four Madhhabs. Its altitude to initiate the time of night prayer is −19° according to Imâm-i-a'zam (Abû Hanîfa, the leader of Hanafî Madhhab), and −17° according to the two Imâms (called 'Imâmeyn', namely, Imâm Muhammad and Imâm Abû Yûsuf, two of Imâm-i-a'zam's most eminent disciples), and also according to the other three Madhhabs. The altitude to indicate the beginning of early afternoon is the meridian altitude (ghâya irtifâ'), which, in its turn, is the algebraic addition of the (Sun's) declination and complement of latitudinal degrees. Mer'î-haqîqî **noon time** (zawâl) is when the center of the Sun is observed to have culminated, (i.e., to have reached the elevation called ghâya irtifâ',) with respect to true horizon. The altitudes for the times of early afternoon and late afternoon ('asr) change daily. These two altitudes are determined daily. Since it is not always possible to determine (by observation) the time when the limb of the Sun reaches the altitude from the apparent horizon for a certain prayer, books of fiqh explain the signs and indications of this mer'î time, which means to say that the apparent times of namâz are the mer'î times, not the mathematical times. Muslims who are unable to see these indications in the sky, and calendar-makers as well, calculate the mathematical times when the limb of the Sun reaches the altitudes with respect to the lines of surface horizon after noon; since timepieces will show the mer'î times when they reach the mathematical figures thereby calculated, these people will have performed their prayers of namâz at the so-called **mer'î times**.

By calculation, the mathematical times when the Sun reaches the prescribed altitudes from the true horizon are determined. That the Sun has reached a certain mer'î time (or altitude) is observed eight minutes and twenty seconds after the time thereby calculated; this time (of observation) is called **mer'î time.** In otherwords, the mer'î time is eight (8) minutes and twenty (20) seconds after the mathematical time. Since the time of true noon and that of adhânî sunset according to which timepieces are adjusted to begin are mer'î times, the riyâdî times indicated by timepieces are mer'î times. The times printed on calendars, mathematical as they are, change into mer'î times on timepieces. For instance, if a certain time determined by calculation is, say, three hours and fifteen minutes, timepieces demonstrate this moment of three hours and fifteen minutes as the mer'î time. First the **haqîqî mathematical times,** when the center of the Sun reaches the altitudes prescribed for the prayers of namâz from the true horizon, are determined by calculation. Then these times are converted into **shar'î mathematical times** through a process performed with the period of time called **Tamkîn**. Hence, there is no need for also adding 8 minutes and 20 seconds to the riyâdî times represented on timepieces. The difference of time between true time and shar'î time for a certain prayer (namâz) is termed the time of **Tamkîn**. The time of Tamkîn for each prayer time is approximately the same.

The time for morning prayer at a certain location begins, in all four Madhhabs, at the end of **shar'î** (canonical) **night,** which in turn is when the whiteness called **fajr sâdiq** is seen at one of the points on the line of apparent horizon (ufq-i-zâhirî) in the east. This time is also the beginning of fast. Chief of Astronomy Department Ârif Beg reports: "Because there are weak reports saying that the fajr sâdiq begins when the whiteness spreads over the horizon and the altitude of the Sun is -18° or even -16°, it is judicious and safe to perform the morning prayer 15 minutes later than the time shown on calendars." To determine the Sun's altitude at the time of dawn, the time of dawn is determined by observing the line of apparent horizon and in the meanwhile directing our attention to our timepiece, in a night when the sky is clear. The time determined thereby will match one of the times calculated to correspond with various altitudes, and the altitude wherewith the matching time corresponds is the altitude of dawn (fajr). An identical method is used to determine the altitude of shafaq (disappearance of evening twilight). Throughout centuries Islamic scholars have adopted the altitude for fajr as –19°, rejecting any other values as 'incorrect values'. According to Europeans, dawn (fajr) is the spreading of the whiteness, and the Sun's altitude is –18° at dawn. Muslims' religious tutors are not Christians or people who have not adapted themselves to any of the (four) Madhhabs; our tutors are Islamic scholars. The time of morning prayer ends at the end of **solar night**, which is when the preceding [upper] limb of the Sun is observed to rise from the line of apparent horizon.

The **celestial sphere**, with the Earth at its centre like a point, is a large sphere on which all the stars are projected. Prayer times are calculated by using the **arcs of elevation**, which are imagined to be on the surface of this sphere. The two points at which the axis of the Earth intersects the celestial sphere are called **celestial poles**, (which are directly above the poles of the Earth). Planes passing through the two poles are called **planes of declination.** Circles that these planes form on the celestial sphere are called **circles of declination.** Planes containing the plumb-line of a location are called **azimuth planes** (or vertical planes). The circles formed by the imagined intersection of planes containing the plumb-line of a location and the celestial sphere are called the **azimuth** or **altitude circles** (or **verticals**). The azimuth circles of a given location are perpendicular to the location's horizons. At a given location, there is one plane of declination and an infinite number of azimuth circles. The plumb-line of a location and the axis of the Earth (may be assumed to) intersect at the centre of the Earth. The plane containing these two lines is both the azimuthal and the declination plane of the location. This plane is called the **meridian plane** of the location. The circle of intersection of this plane with the celestial sphere describes the **meridian circle**. A location’s meridian plane is perpendicular to its plane of true horizon and divides it by half. The line whereby it cuts through its plane of true horizon is termed the meridian line of the location. The arc, (GN), between the point, N, where the azimuth circle (vertical) passing through the Sun intersects the true horizon, and the centre of the Sun, G, is the **arc of true altitude** of the Sun at a given location at a given time. The angular value of that arc is the Sun’s true altitude at that place at that moment. The Sun crosses a different azimuth circle every moment. The arcs measured on an azimuth circle between the point, Z, at which the circle passes through the Sun’s (upper) limb, and the point at which it intersects the tangential, apparent, mathematical and surface horizons are called the Sun’s **apparent altitudes** with respect to these horizons. Angular values of these arcs represent the Sun’s **apparent altitudes** with respect to the so-called horizons. The Sun’s surface altitude is greater than its true altitude. At different times the Sun is at an equal altitude from these horizons. The true altitude is equal to the value of the geocentric angle subtended by the celestial arc of true altitude. The angular values of an infinite number of arcs of a variety of lengths that are bounded by the sides of this angle and which are parallel to the so-called celestial arc as well as to one another, are equal to one another and to the true altitude. Every pair of straight lines that describe the other altitudes originate from the point where the plumb-line of the place of observation intersects the horizon. The plane passing through the centre of the Earth perpendicular to its axis is called the **equatorial plane.** The circle of intersection of the equatorial plane with the Earth is called the **equator.** The place and the direction of the equatorial plane and those of the equatorial circle never change; they divide the Earth into two equal hemispheres. The value of the arc of declination between the Sun’s center and the equatorial plane represents the **Sun’s declination.** The whiteness before the apparent sunrise on the line of apparent horizon begins two degrees of altitude prior to the redness; in other words, it begins when the Sun ascends to an altitude of 19° below the apparent horizon. This is a fact stated in a fatwâ[1]. Nonmujtahids do not have the right to change the fatwâ. It has been reported in Ibn ’Âbidîn (Radd-ul-muhtâr) and in the calendar by M.Ârif Beg that some ’ulamâ have said that it begins when the Sun is a distance of 20° (from the apparent horizon). However, acts of worship that are not performed in accordance with the fatwâ are not sahîh (valid).

The Sun’s daily paths are circles on the (imaginary inner surface of the) celestial sphere and which are parallel to one another and to the equatorial plane. The planes of these circles are (approximately) perpendicular to the Earth’s axis and to the meridian plane, and intersect the horizontal planes of a given location obliquely, which means that the Sun’s daily path does not intersect the line of apparent horizon at a right angle. The azimuth circle through the Sun is perpendicular to the line of apparent horizon. When the Sun’s centre is on the observer’s meridian, the circle of declination going through its center and the location’s azimuthal circle coexist, and its elevation is at its daily maximum from the true horizon, (the event termed culmination).

Muslims who (possess the conditions wherein they can) observe the Sun are accredited to avail themselves of the **time of apparent zuhr**, i.e. the **apparent time of early afternoon prayer**. This mer’î time begins as the Sun’s following (trailing) limb departs from the apparent region of zawâl. The Sun rises from the surface horizon, i.e., from the line of apparent horizon, which we see, of a given location. First, the **time of apparent-mer’î zawâl** begins when the preceding (leading) limb of the Sun en route for its culmination with respect to (the eastern arc of) the surface horizon, which is the **line of apparent horizon** that we observe, reaches the celestial (circle of apparent) zawâl region relating to this maximum altitude. This moment is determined when decline in the length of the shadow of a rod (erected vertically on a horizontal plane) is no longer perceptible. Thereafter the **time of true-mer’î zawâl** is when the centre of the Sun rises to the location’s celestial meridian circle, [i.e. when it has traversed the mid day arc peculiar to that location,] or, in other words, when it culminates with respect to the true horizon. Thereafter, when its following limb descends to the point of culmination with respect to the western arc of the surface horizon of the location, the **time of apparent**

zawâl ends, the shadow is observed to begin gaining length, and hence the beginning of the **time of apparent-mer'î zuhr**. The motion of the Sun and that of the tip of the shadow are imperceptibly slow as the Sun ascends from the apparent zawâl time to true zawâl time, and as it descends thence to the end of the apparent zawâl time, because the distance and the time involved are negligibly short. When the following limb descends to the point of culmination with respect to the shar'î horizon on the western arc of the line of surface horizon of the location, the **time of apparent mer'î zawâl** ends and the **time of shar'î mer'î zuhr** begins. This time is later than the time of true zawâl by a period of **Tamkin**, because the difference of time between the true and the shar'î zawâls is equal to the difference of time between the true and the shar'î horizons, which in turn is equal to the period of time called **Tamkin**. The zâhirî (apparent) times are determined with the shadow of the rod. The shar'î times are not found with the shadow of the rod. The true time of zawâl is found by calculation, (length of) time termed **Tamkin** is added to this, hence the riyâdî (mathematical) shar'î time of zuhr. The result is recorded in calendars. The shar'î time of zuhr continues until the 'asr awwal, which is the time when the shadow of a vertical rod on a level place becomes longer than its shadow at the time of true zawâl by as much as its height, or until 'asr thânî, which is the time when its shadow's length increases by twice its height. The former is according to the Two Imâms [Abû Yûsuf and Muhammad ash-Shaybânî], and also according to the other three Madhhabs, and the latter is according to al-Imâm al-a'zam.

Although **the time of late afternoon prayer** begins at the end of the time of early afternoon prayer and continues until the following limb of the Sun is observed to set below the line of apparent horizon of the observer's location, it is harâm to postpone the prayer until the Sun turns yellow, an event that takes place when the distance between the Sun's lower [preceding] limb and the line of apparent horizon is a spear's length, which is five angular degrees. This is the third one of the daily three times of kerâhat (explained towards the end of this chapter). Calendars in Turkey contain time-tables wherein times of late afternoon prayers are written in accordance with 'asr awwal. For (performing late afternoon prayers within times taught by Imâm a'zam and thereby) following Imâm a'zam, late afternoon prayers should be performed 36 minutes, (in winter,) and 72 minutes, (in summer,) after the times shown on the aforementioned calendars. In regions between latitudes 40 and 42 a gradational monthly addition of the numerical constant of 6 minutes to 36 from January through June and its subtraction likewise from 72 thenceforward through January, will yield monthly differences between the two temporal designations termed 'asr, (i.e. 'asr awwal and 'asr thânî).

The time of evening prayer begins when the Sun apparently sets; that is, when its upper (following) limb is seen to disappear below the line of apparent horizon of the observer's location. The shar'î and the solar nights also begin at this time. At locations where apparent sunrise and sunset cannot be observed, and in calculations as well, the shar'î times are used. When (the first beam of) sunlight strikes the highest hill at one of these locations in the morning, it is the shar'î time of sunrise (at that location). Conversely, in the evening, when sunlight is observed to withdraw from there, it is the mer'î-shar'î time of sunset. The adhânî timepieces are adjusted to twelve (12) o'clock at this moment. The time of evening prayer continues until the time of night prayer. It is sunna to perform the evening prayer early within its time. It is harâm to put it off till the time of **ishtibâk-i-nujûm**, which is when the number of visible stars increase, or, in other words, after the following limb of the Sun has sunk down to an altitude of 10° below the line of apparent horizon. For reasons such as illness, long-distance journeys, or in order to eat food that is ready, it might be postponed until that time.

The time of night prayer begins, according to the Imâmeyn, with 'ishâ-i-awwal, that is, when the redness on the line of apparent horizon in the west disappears. The same rule applies in the other three Madhhabs. According to Imâm-al-a'zam it begins with 'ishâ-i-thânî; that is, after the whiteness disappears. It ends at the end of the shar'î night; that is, with the whiteness of fajr-isâdiq according to the Hanafî Madhhab. The disappearing of redness takes place when the upper (following) limb of the Sun descends to an altitude of 17° below the surface horizon. Thereafter, the whiteness disappears when it descends to analtitude of 19°. According to some scholars in the Shâfi'î Madhhab, the latest (âkhir) time for night prayer is until the shar'î midnight. According to them, it is not permissible to postpone the performance of night prayer till after the shar'î midnight. And it is makrûh in the Hanafî Madhhab. In the Mâlikî Madhhab, although a night prayer that has been performed by the end of the shar'î night is sahîh (valid), it is sinful to postpone it till the end of the initial one-third of the night and perform it thereafter. Muslims who have somehow failed to perform the earlyafternoon or the evening prayer of a certain day before the end of the time prescribed by the Two Imâms should not make the worse choice by (putting off the prayer till the unanimously definite end of the prayer time, which is widely expressed by Muslims in Turkey as) 'leaving the prayer (namâz) to qadâ'; they should perform them according to al-Imâm-al-a'zam's prescription; and in that case, they should not perform the late afternoon and the night prayers of that day before the times prescribed for these prayers by al-Imâm-al-a'zam. A prayer is accepted as to have been performed within its prescribed time if the initial takbîr has been uttered, according to the Hanafî Madhhab; and if one rak'a of the namâz has been completed, according to the Madhhabs named Mâlikî and Shâfi'î; before the end of the prescribed time. A. Ziyâ Beg notes in his book **'Ilm-i hey'et**:

"The further ahead in the direction of the poles, the farther apart from each other are the beginning of morning prayer, i.e. the breaking of morning twilight, and sunrise; and for the same matter, the beginning of night prayer, i.e. the (end of) evening dusk, and sunset, and, also incidentally, the closer to each other are the initial times of (a certain day's) morning prayer and the night prayer (of the previous day). Prayer times of a location vary depending on its distance from the equator, i.e., its degree of latitude, φ, as well as on the declination, δ, of the Sun, i.e., on months and days." [At locations whose latitudinal value is greater than the complement of declination, (i.e. when $\varphi>90-\delta$, or when $\varphi+\delta>90$,) days and nights never take place. During the times when the sum of latitude and declination is 90°-19° = 71° or greater, i.e., $90°-\varphi\leq\delta+19°$ or $\varphi+\delta\geq 71°$; for example, during the summer months when the Sun's declination is greater than 5°; fajr (dawn, morning twilight) begins before the shafaq (evening dusk, evening twilight) turns into complete darkness. So, for instance, in Paris which is on latitude 48°50', the times of night and morning prayers do not start from 12 through 30 June. In the Hanafî Madhhab, the time of a certain prayer is the reason (sabab) for performing that prayer. The prayer does not become fard unless the reason arises. Therefore, these two prayers (salâts) do not become fard at such places. However, according to some scholars, it is fard to perform these two salâts at the times they are performed in nearby countries or places. [During the periods of time (12 to 30 June) when the times of these two prayers of namâz do not virtually begin, it is better to (try and determine the times that these two prayers were performed on the last day of the period during which such conditions existed as their prescribed times virtually began, and to) perform them at the times determined.]

The time of **Dhuhâ** begins when one-fourth of nehâr-i-shar'î, i.e., the first quarter of the canonically prescribed duration of daytime for fasting, is completed. Period of time half the nehâr-ishar'î is called the time of **Dhahwa-i-kubrâ.** In adhânî time (reckoned from shar'î sunset) Dhahwa-i-kubrâ=Fajr+(24- Fajr)÷2=Fajr+12-Fajr÷2=12+Fajr÷2. Hence, half the time of Fajr gives the time of Dhahwa-i-kubrâ reckoned from 12 in the morning. (For example), in Istanbul on the 13th of August, the time of dawn (fajr) in standard time is 3 hours 9 minutes, the standard time of sunset is 19 hours 13 minutes, and therefore, daytime lasts 16 hours 4 minutes and the standard time of Dhahwa-i-kubrâ is 8:02+3:09=11 hours 11 minutes. In other words, it is equal to half the sum of times of imsâk and iftâr in standard time.

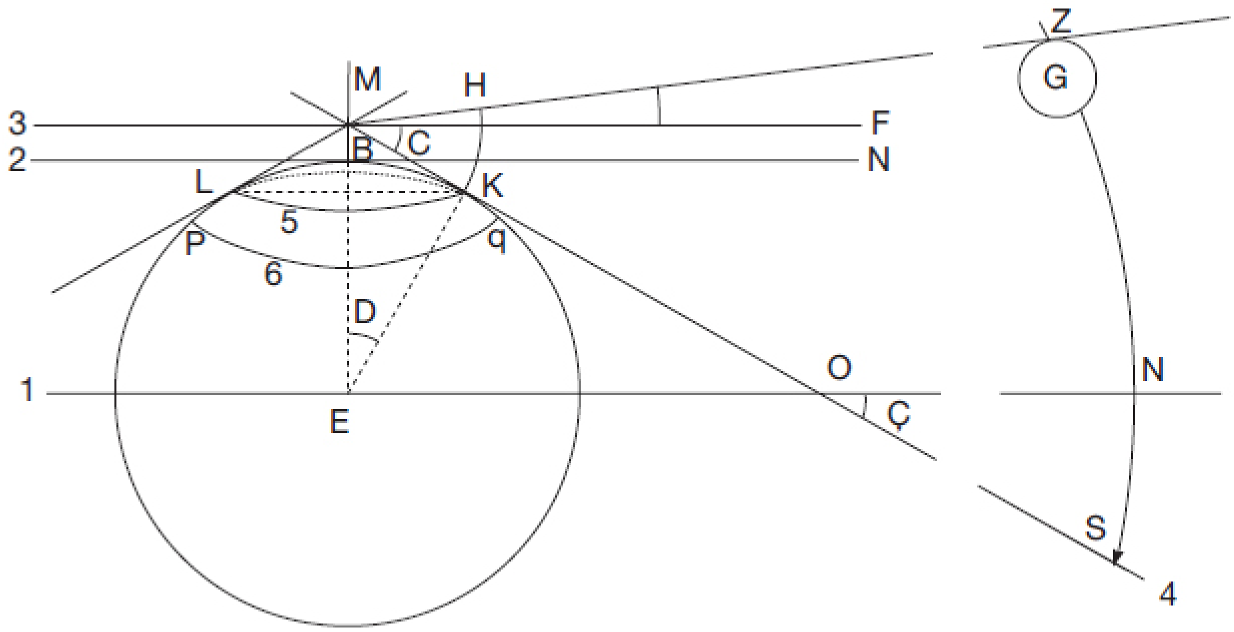

Fig. 1–A

K = The point at which the azimuthal plane through the Sun intersects the line, (LK), of apparent horizon.

MS = The plane ufq-i hissî (tangential horizon) tangent to the Earth at point K, perpendicular to the plumb-line at K, is termed the observer's surface horizon.

HK = The altitude of the (upper) limb of the Sun with respect to point K, which is on the line of apparent horizon. This altitude is equal to the altitude ZS of the Sun with respect to the surface horizon.

D = C = Ç = Angle of dip of horizon.
M = A high place of the location.
ZMF = Angle of the Sun's mathematical altitude.

ZS = The arc of azimuthal circle giving the altitude of the Sun with reference to the surface horizon. This angle is equal to the angle subtended by the arc HK.

O = A point on the straight line of intersection of planes of true and surface horizons.
Planes of horizon 1. True horizon; 2. Tangential horizon; 3. Mathematical horizon; 4. Surface horizon; 5. Line of apparent horizon; and also Plane of mer'î horizon. 6. Line of Canonical (Shar'î) horizon; and plane of Canonical horizon.

G = The Sun as observed from the Earth.
GN = True altitude of the Sun.
B = Lowest place of the location.

Since the amount of refraction of light by the atmospheric layers increases as the Sun draws near the line of apparent horizon, at level places such as sea surfaces and planes it appears to have risen as the upper (preceding) limb of the Sun is still below the line of apparent horizon by about 0.56 angular degrees. Conversely, its disappearing below the horizon in the evening takes place after its upper (following) limb has descended to an equidistant position below the horizon.

Planes perpendicular to the plumb-line of a location, i.e., to the Earth's radius through that location, are called the **ufqs=horizons** of the location, the Ufq-i-sat-hî (surface horizon) being the only exception. Six types of horizon may be defined. The locations and directions of the horizons are not constant. They vary, depending on the locations of the observer. **Ufq-i-haqîqî=True horizon** is the one passing through the Earth's centre. **Ufq-i-hissî=Tangential horizon** is an infinite plane passing through the lowest point B of the location, that is, a plane tangent to the Globe at point B. The angle formed at the Sun's centre by the two straight lines, one from the Earth's centre and the other from the Earth's surface, is called the Sun's **horizontal parallax=ikhtilâf-i-**

manzar. Its annual mean value is 8.8 angular seconds. It is the difference between the altitude of the Sun's centre with respect to two different horizons, the true horizon and the riyadî (mathematical) or tangential horizon. Parallax results in a delay in the sighting of lunar and solar risings. The horizontal plane, (F), passing through the point M of a certain height where the observer is located is called the observer's **ufq-i riyâdî=mathematical horizon.** The **khat ufq-i-zâhirî=line of apparent horizon** is the circle LK described as the line of tangency of the cone formed by the revolution about the plumb-line through M, of the straight line MK, projecting from the observer's eye at M and tangent to the Globe at K. The plane containing this circle and perpendicular to the plumb-line through M is called the observer's **ufq-i-mer'î=visible horizon**; and the surface of this cone is the observer's **ufq-i-sathî** (surface horizon). The **line of apparent horizon** appears to the observer, who stands at a certain height, as a circular line around which the sky and the lowest points, such as sea surfaces and plains, on the Earth's surface intersect. This circular line is formed by the points of intersection between the visible horizon and the Earth's surface. There is a plane of azimuth containing every point of this circle. The plane of tangential horizon going through point K, which is intersected by the plane of azimuth containing the Sun, intersects the plane of azimuth at a right angle and along line MS. This tangential horizon, plane MK, is called the observer's **ufq-i-sathî=surface horizon**. There are various surface horizons for various altitudes at a location. The points K, whereat each of these horizons is tangent to the Earth's surface, make up the (circular line termed) line of apparent horizon. The direction of the ray projecting from the observer's eye, i.e. the line MS, is called the **line of surface horizon**. The vertical (azimuthal) arc, ZS, is the altitude of the Sun with respect to the surface horizon. The arc ZS subtends the angle inscribed between the two straight lines projecting from the observer's eye to the two ends of this arc. As the Sun moves, the point of tangency K of the surface horizon MS glides on the line of apparent horizon and, thereby, the surface horizon changes momently. The observer will see the Sun when he looks at the point H at which the straight line MZ from the observer to the Sun intersects the arc HK from K, drawn parallel to ZS, the arc of altitude. He will perceive this arc as the altitude of the Sun with respect to the line of apparent horizon. The angle subtented by this arc HK is identical with that subtended by ZS, the altitude of the following (upper) limb of the Sun with reference to the surface horizon. Therefore, the **apparent altitude** HK is used for the altitude with respect to the surface horizon. The Sun sets when it is at point S in the sky. The observer perceives as if it sets at point K on the Earth. Once the Sun and the stars go below the surface horizon of a location, i.e., when their altitude with reference to this horizon becomes zero, all the observers who share this horizon see them set. The observer at point M sees the Sun set at point K of the surface horizon. In other words, the time of sunset for the observer at point M is when the altitude of the upper limb of the Sun attains zero with respect to the surface horizon. Likewise, the other prayer times for the observer are determined on the basis of shar'î altitudes with respect to the surface horizons. Since the shar'î altitude of the Sun with respect to the surface horizon, ZS, is perceived by the observer at point M as the altitude HK with respect to the line of apparent horizon, the **apparent altitudes,** HK, measured with reference to the apparent horizon are used for determining the prayer times. These altitudes are greater than those with respect to the observer's mathematical, tangential, visible and true horizons. The difference between the altitude ZS with respect to the surface horizon and the arc ZN with respect to the true horizon is called the **zâwiya inhitât-i ufq=the angle of dip of horizon** for the height of point M. The arc of azimuthal circle equal to the angle of dip of horizon, i.e. the arc NS, is the **dip of horizon. Shar'î times**, which are recorded in calendars, are used in mountainous places where the apparent horizon cannot be observed.

Mathematical, tangential, and mer'î (observed, visible) horizons are identical for an observer at the lowest point. At this lowest point, B, there is not a surface horizon, the line of apparent horizon being a small circle around B, and the altitude with respect to this line and the altitudes with respect to all the other horizons being the same. As the point of observation gains elevation, so does the observer's mathematical horizon; thereby their tangential horizon changes into their surface horizon; and their line of apparent horizon descends towards their true horizon and widens. Radius of each of thereby widening circles formed by the descending lines of apparent horizon demarcates an arc to subtend the angle D, which in turn is equal to the angle of dip of horizon. The arcs ZS, which represent the Sun's altitudes with respect to the surface horizon, are higher than the true altitude by the same angular value as that of the dip of horizon.

The Sun's reaching the time of zawâl with respect to a horizon means its culmination with respect to that horizon. When the observer is at the lowest place of a location the Sun's regions of zawâl with respect to all horizons and to the line of apparent horizon converge at one point, and the diurnal arc of the Sun's daily path intersects the meridian at point A, **–as is seen on Figures 1 and 2–**, which is mid-point of the diurnal part of its daily path. This point is called the **region of true zawâl.** As for observers who are at higher places and who (possess the conditions wherein they can) observe the Sun; their **Regions of apparent zawâl** are **circles of regions of zawâl** formed around the celestial region of true zawâl by the points of culmination with respect to the circular lines of apparent horizon peculiar to the heights they occupy. As the Sun moves along its path, it meets with each of these circles at two points. When it reaches the first point, the **time of apparent zawâl** begins. The end of the time of apparent zawâl is when the Sun reaches the second point. As the observer's position becomes higher, dip of horizon takes place and the circles of apparent horizon become larger. And so do the so-called celestial **circles of regions of zawâl**, so that their radii produce arcs subtending angles, equal to the angles, (represented by angle D in fig. 1-A) subtended by their terrestrial counterparts, i.e. arcs produced by the radii of the circles of apparent horizons. When the observer goes up to the highest point of their location, the circle of celestial region of zawâl becomes the greatest and the outermost. This greatest circle of region of zawâl is called the observer's **Shar'î region of zawâl**. The surface horizon of an observer at the highest point of a location is called the observer's **ufq-i-shar'î**. The altitude of the Sun's (upper) limb with respect to the shar'î horizon is called the **shar'î irtifâ'**. The preceding limb of the Sun enters the circular region of shar'î zawâl when it culminates with respect to the place of sunrise on the shar'î horizon. A hill so far from a location as the shaded and the illuminated regions on it are not distinguishable to the naked eye during the time of isfirâr, is not considered within the limits of that location. The radius of the circle of shar'î region of zawâl subtends an angle equal to the angle of dip of horizon for an observer (supposed to be) on the highest hill of the location. The circles representing times of zawâl are not visible; the Sun's getting in and out of these circles can be determined from the shortening and elongation of the shadow of a vertical rod erected on a level ground.

In the section on the mustahabs to be observed by a fasting Muslim in Ibn 'Âbidîn and in the annotation to **Marâq al-falâh** by at-Tahtâwî, it is noted, "Of two Muslims supposed to be fasting, the one who lives at a lower place, and who therefore observes the apparent sunset earlier, breaks fast earlier than the one living at a higher place, [since Islam recognizes the apparent times, not the true times, as canonically acceptable for those who (can) see the Sun.] For those who are unable to observe the sunset; 'sunset' is when the hills in the east darken." In other words, it is the apparent sunset that would be observed by people living on the highest hill, which in turn means sunset with respect to the shar'î horizon. It is noted also in the book **Majma'al-anhur** and the Shafi'î book **Al-anwâr li-a'mâl-il abrâr** that the **shar'î sunset** is to be taken into account by those who are not able to observe the sunset; and it is determined by calculation.

For easy determination of the times of early and late afternoon prayers, 'Abd al-Haqq as-Sujâdil, who was matured in the suhba of Muhammad Ma'thûm al-Fârûqî as-

Sirhindî, describes a method in his Persian book **Masâ'il-i sharh-i Wiqâya,**printed in India in 1294 [1877 A.D.]:

"A circle is drawn on a level ground taking sunlight. This circle is called the **Dâ'ira-i Hindiyya=the Indian circle**. A straight rod, with a length equal to the radius of the circle, is erected at the centre of the circle. The top of the rod must be equidistant from three different points on the circle to make it certain that it is precisely vertical. This vertical rod is called the **miqyâs=gnomon.** Its shadow extends beyond the circle on the western side before noon. As the Sun moves higher up, i.e., as its altitude increases, the shadow shortens. A mark is made at the point where the tip of the shadow enters the circle. Another mark is made at the point where the tip of the shadow exits the circle as it elongates eastwards. A straight line is drawn from the centre of the circle to the midpoint of the arc between the two marks. This straight line is called the **khat nisf-un-nahâr=the meridian line of the location.**" The meridian line extends in the northsouth direction. When the preceding limb of the Sun reaches its maximum altitude from the line of apparent horizon of the location, the **time of zâhirî** (apparent) **zawâl** begins. It is no longer possible now to perceive the shortening of the shadow. Next, the centre of the Sun comes to the meridian and is at its maximum altitude from the true horizon. This is **the time of haqîqî** (true) **zawâl**. At the time of true zawâl, the times of zawâl in terms of mean time are not subject to variation on account of latitudinal variation. As the Sun departs from this point, the shadow also departs from the meridian line, though imperceptibly. The apparent zawâl time ends when the following limb descends to its apparent maximum altitude with reference to the sunset spot on the line of apparent horizon. Now the **time of apparent zuhr** begins. The shadow begins observably to lengthen. The middle of the time during which the length of the shadow remains unchanged is the **haqîqî (true) zawâl time.** As the Sun's center transits the meridian, its momentary passage is observed from London with telescopes and thereby zawâlî timepieces are adjusted. At this mer'î haqîqî zawâl time, the haqîqî (true) time is twelve. The algebraic addition of this twelve to the equation of time yields the **meantime** beginning, i.e. twelve, of the day on the local timepiece. The riyâdî times found by calculation show also the mer'î times on timepieces. This **mer'î zawâl time,** which is the beginning for the meantime clocks, is eight minutes and twenty seconds after the **riyâdî zawâl time,** which is the time when the Sun reaches the zawâl. The ratio between the height of anything erected at right angles to the Earth's surface and the length of its shortest shadow, **fay-i-zawâl**, varies with latitude and declination.

A pair of compasses is opened by a length of fay-i-zawâl. The sharp point of the compasses is placed at the point where the meridian line meets the (Indian) circle and a second circle, whose radius is the distance between the centre of the first circle and the point whereon it intersects the extension of the line of meridian beyond the first circle, is drawn. It is **the time of apparent 'asr awwal** when the shadow of the gnomon reaches the second circle. The second circle must be drawn anew daily. Fay-i-zawâl is used only to find the times of early and late afternoon prayers. It is not practicable in finding the times of other prayers.

It is written in the books **Majma'al-anhur** and **Riyâdh-unnâsihîn:** "The time of zuhr begins when the Sun is at zawâl, i.e., when its following limb begins to descend from the maximum altitude it has ascended with respect to the line of apparent horizon. To determine the time of zawâl, a rod is erected. It is **the time of zawâl** when the shortening of its shadow stops, that is, when it neither shortens nor lengthens. It is not permissible to perform namâz during this time. The time of zawâl is over when the shadow begins to lengthen." The maximum altitude mentioned in the aforenamed books is not the altitude with respect to the true horizon. Two positions are noted: one is when the preceding limb ascends to its maximum altitude from the surface horizon, i.e. with respect to the eastern arc of the line of apparent horizon; and the other is when the following limb begins to descend from its maximum altitude from the surface horizon, i.e. with respect to the western arc of the line of apparent horizon. As a matter of fact, it is written in the annotation to the commentatory book **Imdâd** that the line of apparent horizon, not the true horizon, is to be taken into account in determining the time. The "time of apparent zawâl" commences when the Sun's preceding limb reaches its maximum altitude from the surface horizon, or from (the eastern arc of) the line of apparent horizon. The time of apparent zawâl ends when the following limb begins to descend from its maximum altitude from the surface horizon with respect to the place of sunset on the line of apparent horizon, and thenceforth the time of apparent zuhr commences. At this moment the shadow of the gnomon is imperceptibly longer. The apparent time of late afternoon prayer ('asr) is when the length of this shadow increases by the length of the gnomon. The time of true zawâl is only an instant. On the other hand, the times of apparent zawâl based on the preceding and following limbs are when the respective limbs enter and exit the circles (imagined) on the celestial sphere and termed **Regions of apparent zawâl**, whose centers coexist with the points of true zawâl and radiuses equal the angular value of the **dip of horizon** pertaining to the height of the observer's location. The region of apparent zawâl is not an (instantaneous) point; it is an arc between the two points whereby (each of) the so-called circles intersect(s) the Sun's (apparent daily) path. The greatest of these circles is the **Circle of region of shar'î zawâl**. In Islam, the time of zawâl, i.e. midday, is the period of time between the instant when the Sun's preceding limb enters this shar'î circle and the instant when its following limb exits the circle. The **time of shar'î zawâl** begins when the Sun's preceding limb enters the circle. The shar'î zawâl time ends when the Sun's following limb exits the circle, and then the **shar'î zuhr time** begins. This time is determined by calculation and recorded in calendars.

The six-rak'at salât performed after the fard of evening salât is called the salât (namâz) of **awwâbîn.**

The job of understanding, working out, determining, and explaining the times of acts of worship requires Islamic knowledge ('ulûm ad-dîn). The 'ulamâ' (authorized Islamic scholars) of (the branch of Islamic knowledge termed) **fiqh** wrote in their books of fiqh the teachings which mujtahids (extracted from the Qur'ân al-kerîm and hadîth-i-sherîfs and) explained. It is permissible to exercise oneself in the recalculation of the prescribed times, (which have already been explained by mujtahids.) Results of such calculations, however, are conditional on the aforesaid Islamic scholars' approval. It is noted in the section dealing with (the essentials of) "facing the Qiblâ in salât" in Ibn 'Âbidîn, and also in **Fatâwâ-i Shams adîn ar-Ramlî**, that it is jâ'iz (permissible) to determine the times of salât and direction of the Qibla by calculation. It is noted in **Mawdû'ât-ul-'ulûm:** "It is fard kifâya to calculate the prayer times. It is fard for Muslims to know the beginning and the end of the prayer times from the position of the Sun or from the calendars approved by Islamic scholars."

The Earth rotates about its axis from west to east. In other words, an overhead view of it, like that of a globe placed on a table (with the North Pole pointing upwards), would reveal that it rotated in a counterclockwise direction. This is called the **true** (direct, prograde) **motion.** The Sun and the fixed stars appear to make a revolution per day from east to west. This is called the **retrograde motion.** The time between two successive meridianal transits of a star at a certain location is defined as one **sidereal day.** One-twenty-fourth of this period is one **sidereal hour.** The time interval between two successive transits of the centre of the Sun across the meridian, that is, the time between successive instants of true zawâl is called **one true solar day.** Meanwhile, the Earth moves from west to east around the **ecliptic** and completes one revolution per year around the Sun. Due to this motion of the Earth, the Sun appears to move from west to east on the ecliptic plane, rotating about the **ecliptical axis** through the Earth's centre perpendicular to the ecliptic plane. The average speed of this translational movement is about 30 kilometres per second, though it is not constant. Since the orbit of the Earth on the ecliptic plane is not circular but **elliptical,** the angles subtended by the arcs travelled in equal intervals are not equal. The smaller its distance to the Sun, the higher its speed. As a result of this movement of the Earth, the Sun is slower than the stars by about 4 minutes per day, thus completing its daily revolution about 4 minutes later than the stars. Therefore, the "true solar day" is about 4 minutes longer than the sidereal day. This extra time slightly varies from day to day around 4 minutes. The second reason for the variation of the lengths of true solar daytimes is that the axis of the Earth is not perpendicular to the plane of ecliptic. There is an angle of about 23°27' between the axis of the Earth and the ecliptical axis. This angle never changes. The third reason is that the maximum altitude of the Sun changes daily. The ecliptic and the equatorial planes intersect along a diameter of the Earth. There is an angle of about 23°27' between these two planes. This diameter of intersection is called the **line of nodes**, (or the nodal line.) This angle never changes. The average direction of the Earth's axis does not change as it revolves round the Sun. It remains parallel to itself. On the 22nd of June, the axis of the Earth is tilted in such a direction as its northern part is inclined towards the Sun with respect to the (upright position of the) axis of the ecliptic, so that more than half of the northern hemisphere takes sunlight. The declination of the Sun is about +23.5°. When the Earth arrives at a point about one-fourth of the length of its yearly round, the projection of axis of the Earth on the ecliptic deviates from the Sun-Earth direction by about 90°. At this time the line of nodes passes through the Sun; and the Sun's declination is zero. When the Earth travels one-half of its yearly orbital round, the perpendicular projection of the Earth's axis on the ecliptic resumes its former sunward position, with the mere difference that the axis itself, with respect to the (still upright) axis of the ecliptic, is now declined proportionally away from the Sun, whereby the equatorial semi-circle facing the Sun is above (, i.e. to the north of,) the ecliptic plane; less than half of the northern hemisphere and more than half of the southern hemisphere are exposed to sunlight; the Sun is 23.5° below (to the south of) the equator and hence its declination is -23.5°. When the Earth has travelled three-fourths of its yearly orbital route, i.e., on 21st March, the nodal line passes through the Sun and the Sun's declination is again zero. Hasîb Beg notes in his book **Kozmografya**: "The light rays coming nearly parallel to one another are tangent to the Globe around a major circle. This major circle is called the **dâira-i tanwîr=the circle of illumination (the terminator)**. For the first six months during which the Sun is above the equatorial plane, (i.e. north of it,), more than half of the northern hemisphere is on the side of the terminator exposed to the Sun. The plane of illumination defined by this circle passes through the Earth's centre, bisects the Globe, and is perpendicular to the light rays from the Sun. Since the Earth's axis is perpendicular to the equatorial plane, the **angle of illumination** between the plane of illumination and the Earth's axis is equal to the Sun's declination. This is why there are days without nights and nights without daytime at places with latitudes greater than 90°- 23°27'=66°33'. Let us assume another and smaller circle sketched parallel to the circle of illumination 19° away from it on the unilluminated side. The phenomena of fajr (morning twilight, dawn, daybreak) and shafaq (evening dusk, evening twilight) take place within the zone between the two circles. At places where the complementaries to the latitudes are less than (declination+19°), or, in other words, in situations where regional and seasonal conditions concur in such a way as the sum of latitude and declination, (φ+δ), is greater than or equal to 90°-19°=71°, the morning twilight or dawn begins before the evening twilight or dusk disappears." In situations when the Sun's declination is smaller than the latitudinal value of a location, the Sun's culmination takes place at a region south of the observer's zenith. The observed paths of the Sun and the stars are circles parallel to the Equator. The Sun's declination is zero when the daily path of the Sun coincides with the equatorial plane on the Gregorian March 21 and on September 23. On these two days, the durations of the night-time and daytime are equal everywhere on the Earth. Since the nisf fadla is zero, the time of true zawâl in ghurûbî time, and the times of true sunrise and sunset in true solar time are all 06:00 hours everywhere. The shar'î times of zuhr in adhânî time are also shown as 6 in all authentic calendars, because approximately the same amount of time of Tamkin for sunset exists in the time of zuhr as well. Thereafter the Sun's apparent daily paths lapse into an everincreasing digression from its equatorial course, so that the Sun's declination eventually reaches the angular value of +23°27' on June 22, (i.e. at the end of the three months posterior to the vernal equinox on March 21,) and, conversely, –23°27' on December 22, (i.e. at the end of the three months following the autumnal equinox on September 23). These two dates, (i.e. June 22 and December 22,) are when there begins a gradual decrease in the absolute value of the Sun's declination. During the time when the Sun is below (south of) the Equator, the major part of the northern hemisphere is on the sunless, dark side of the terminator. As the Earth rotates about its axis, the Sun rises when the front edge of the small circle of apparent horizon, (termed 'line of apparent horizon',) of a location touches the illuminated one of the two hemispheres divided by the terminator. The Sun rises exactly in the east when its declination is zero. As the declination increases, the points of sunrise and sunset glide along the line of apparent horizon northwards in summerward months and southwards in winterward months (on the northern hemisphere, and vice versa on the southern hemisphere). The arcs of line of apparent horizon, with their angular value daily changing, are called the **si'a=annual** (sunrise and sunset) **amplitudes**. In northern countries, the Sun, after rising, always appears to gain elevation in a direction with southerly obliquity.

One-twenty-fourth of a true solar day is called one **true solar hour.** The lengths of true solar hours change daily. However, the units of time to be adopted (and to be used for civil time-keeping purposes) by using clocks, are required to consist of standardized lengths of days and hours immune to daily fluctuations. Consequently, the **mean solar day** was devised. One-twentyfourth of a mean solar day is called one **mean hour.** Ibn 'Âbidîn calls the former **mu'awwaj** (crooked, not straight or uniform) and the latter **mu'tadil** (uniform, equable) or **falakî** (celestial) in the chapter dealing with menstruation. The length of one mean solar day is the average of the lengths of true solar days in a year. Since there are 365.242216 true solar days in a madârî (orbital, natural, solar, tropical) year, the [hypothetical] Mean Sun travels an angular distance of 360° within this number of days and 59' 08.33" in a mean solar day. Assume that a Mean Sun which travels that distance per mean solar day along the Equator, and the True Sun (on the ecliptic) start moving on a day with the shortest diurnal period of the year. First the true Sun will be ahead. So the true solar day will be shorter than the mean solar day. Until mid-February the distance (against the Mean Sun) between the two suns will increase every day. Thereafter the True Sun will slow down and they will be on the same meridian around mid-April. After that, the True Sun will lag behind the Mean Sun. Increasing its velocity around mid-May the True Sun will catch up with the Mean Sun around mid-June and they will be on the same meridian. Then it will surpass the Mean Sun. Around mid-July it will slow down, and they will be on the same meridian again around mid-August. Next it will lag behind the Mean Sun. By the end of October it will slow down and the difference between them will gradually decrease. Finally they will resume their concurrence at the start. The time it will take the Mean Sun to travel these differences between the two Suns can be calculated by using Kepler's Laws. The difference of time between the two Suns is called the **(Solar) Equation of Time.** The equation of time is positive when the Mean Sun is ahead and negative when it is behind. It varies between about +16 minutes and -14 minutes of time throughout a year. It is zero four times a year when the two Suns are on the same meridian. A point of time in Mean Solar Time can be converted to True Solar Time by adding to it the equation of time if it is + (positive) and subtracting the equation

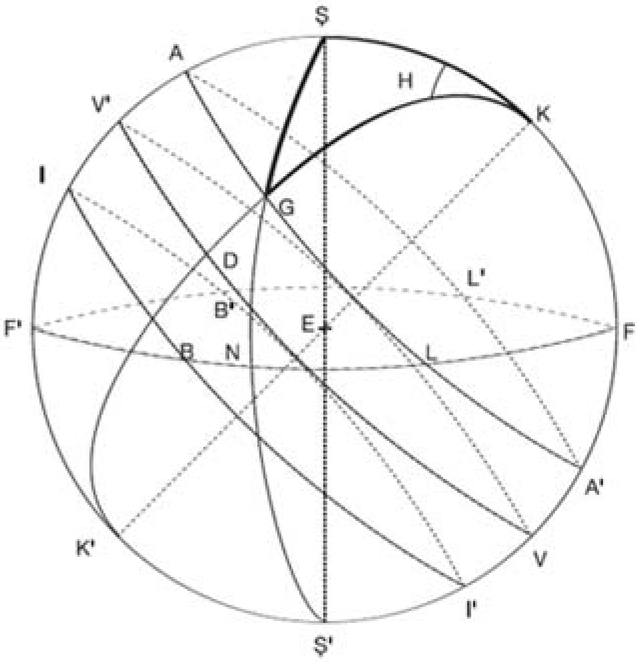

Figure 1

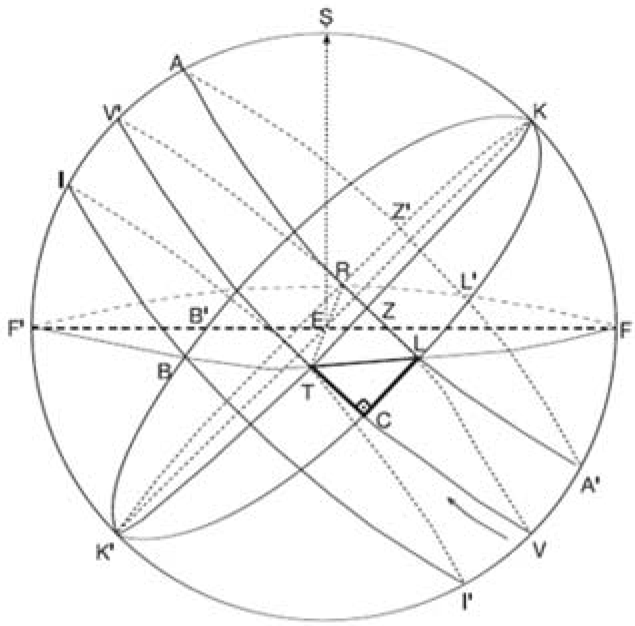

Figure 2

B = Point where the Sun rises on December 22.
T = Point where the Sun rises on March 21 and on September 23.
L = Point where the Sun rises on June 22.
B' = Point where the Sun sets on December 22.
R = Point where the Sun sets on March 21 and on September 23rd.
L' = Point where the Sun sets on June 22.
BI = Semi-diurnal arc (six hours) minus nisf fadla on December 22.
TV' = Semi-diurnal arc on March 21 and September 23.
LA = Semi-diurnal arc (six hours) plus nisf fadla on June 22.
AV' = CL = GD = Declination of the Sun on June 22.
IV' = Minus (southerly) declination of the Sun on December 22.
VTV'R = Celestial equator.
AF', V'F', IF' = The Sun’s maximum elevations (at summer solstice, at the two equinoxes, and at winter solstice, respectively).
A = Point where the Sun culminates on June 22.
KLCK' = Semicircle of declination on June 22.
GN = Arc of the Sun’s true altitude.

KZK'Z' = Circle of declination on March 21, and September 23.
TC = Arc of the equator equal to nisf fadla at sunrise and sunset on June 22.
FK = F'K' = Arcs of polar distance.
FK = ŞV' = Celestial arc subtending observer’s latitude.
H = Angle of fadl-i dâ’ir=hour angle.
E = Observer’s location.
EŞ = Plumb-line direction, (such as that of the observer’s upright posture).
TR = East-West diameter of celestial true horizon.
FEF' = Meridian line.
VKV'K' = Meridian circle.
F = Northern point of the true horizon.
ZL = Arc of Nisf fadla, (excess of semi-diurnal arc, or, conversely, complement of semi-nocturnal arc,) at sunrise on June 22.
ZA = Z'A = The six-hour quarter-arcs on June 22.
Z'L' = Arc of Nisf fadla, (excess of semi-diurnal arc, or, conversely, complement of semi-nocturnal arc,) at sunset on June 22.
LT, BT = Semi-annual sunrise amplitudes.

of time from it if it is - (negative). The daily variations in the equation of time range between +22 seconds and -30 seconds of time per day. **(Please click here to see tables of Equation of Time and Declination of the Sun)**

Ahmed Ziyâ Beg states, "The value of the dip of horizon in angular seconds is equal to the product of 106.92 and the square root of the elevation in metres of the observer from the tangential horizon of the location." Since the highest hill near the observer in Istanbul is Çamlıca with a height of 267 metres, the greatest angle of dip of horizon is 29' (in Istanbul). In the table of daily Tamkin which Tâhir Efendi, Chairman of the Astronomy Department, calculated, –he prepared it when he assumed Office as Director of Cairo Observatory in 1283 A.H. (1866)–; and in the book **Marâsid** by Ismâ'îl Gelenbevî the Virtuous; and in the Turkish book **Mi'yâr-ül-evkât** written by Ismâ'îl Fehîm bin Ibrâhîm Hakkî of Erzurum in the year 1193; and at the end of the calendar for hijrî-solar year 1286 (hijrî-lunar year 1326) prepared by Sayyid Muhammad Ârif Beg, Chairman of the Astronomy Department, it is written: "The angle of dip of horizon in Istanbul is maximally 29', and, at this elevation which is below the true horizon, i.e., below zero, the refraction of light is 44.5'; **nisf kutr-i zâhirî** = **the apparent radius** of the Sun, on the other hand, is at least 15' 45"; these three altitudes result in the sighting of the Sun before true sunrise. The solar parallax, however, causes a delay in the sighting of sunrise. Subtraction of 8.8", the angular amount of the **solar parallax**, from the sum of these three altitudes, yields 1° 29' 6.2", an angular amount termed **the angle of the Sun's altitude**. The period, from the moment when the center of the Sun sets with respect to the true horizon to the moment when its following limb descends by the amount of angular distance (calculated above), so that the following limb dips below the shar'î horizon and daylight reflected on the highest hill (facing the sunset) disappears, is called the **Tamkin**. With the help of the Formula used for determining the prayer times on a certain day (in a certain city, say,) in Istanbul, [and a scientific calculator, e.g., Casio], the temporal values of the complements (fadl-i dâir) of the Sun's altitudes, (0° 0' 0" and -1° 29' 6.2",) at the two times of sunset, i.e., setting of the Sun's center with respect to the true horizon and setting of its upper (following) limb with respect to the cannonical horizon, respectively, are calculated. Since the time of zawâl in terms of true-zawâlî system is zero, the times of two sunsets are the same as the temporal values of their complements thereby determined. The period between the two times of sunset is the **Tamkin**." For instance, on March 21 and on September 23, the angle of the Sun's altitude is 1°29'6.2" and the Tamkin, i.e., the time taken by the center of the Sun to descend that amount of altitude below the true horizon along its trajectory, is 7 minutes 52.29 seconds (for Istanbul). With the variables such as the declination of the Sun and the latitude of the location in the formula of prayer times, period of Tamkin in a certain city varies, depending on the degree of latitude and date. Although the period of Tamkin for a city is not the same for every day or hour, there is a mean period of Tamkin for each city. **Please click here for the table of periods of Tamkin.** As a precaution, 2 minutes is added to the Tamkin determined by calculation, and the mean Tamkin for Istanbul is accepted to be 10 minutes (of time). At any place with latitude less than 44°, the difference between maximum and minimum Tamkins in a year is about one or two minutes. A city has only one Tamkin, which is utilized to find the shar'î time of a certain prayer (namâz) from the true time. There are not different Tamkins for different prayers of namâz. Nor is there a Tamkin applied to apparent times. If a person, believing that the period of Tamkin is something added with precautionary considerations, continues to eat for 3 to 4 minutes after the imsâk (time to start fasting), his fast becomes fâsid (null), as do his fast and evening prayer when he takes the sunset to be 3 to 4 minutes earlier; this fact is written also in the book **Durr-i Yektâ**. Declination of the Sun, Tamkin and equation of time change every moment at a location, and the unit of haqîqî ghurûbî time, (i.e. the time of true sunset,) is slightly different from the unit of haqîqî zawâlî time, (i.e. the time of true zawâl); and therefore, the calculated prayer times are not precisely exact. To be sure of the beginning of a prayer time, 2 minutes of precaution is added to the period of Tamkin calculated.

There are three kinds of (times of) sunset: the first one is the time when the true altitude of the Sun's centre is zero, called the **true sunset** (haqîqî ghurûb)**;** the second one is the time when it is observed that the apparent altitude of the Sun's following limb with respect to the apparent horizon of the observer's location is zero, i.e. when its upper (following) limb disappears below the line of apparent horizon of the location, called the **apparent sunset** (zâhirî ghurûb); the third one is the time when the altitude of the rear (following) limb is calculated to be zero with respect to the shar'î horizon; this kind of sunset is called the **shar'î sunset** (shar'î ghurûb). A city has only one shar'î horizon. It is noted in all books of fiqh that, of these three kinds of sunset, the sighting of the apparent sunset is to be taken as a basis. However, there are different lines of apparent horizons for different heights. Although the sunset with respect to the shar'î horizon is the apparent sunset observed from the highest hill (of the location), the times of these sunsets and those of true sunsets are mathematical times; that is, they are always determined by calculation. At the time of the calculated true sunset, the Sun is observed not to have set yet below the lines of apparent horizons of high places. This shows that the time for evening prayer and for breaking fast begins not at the moments of the (aforesaid) first and second types of sunset, but at a time somewhat later, i.e. at the time of shar'î sunset. First the true sunset, and then the apparent sunset, and finally the shar'î sunset take place. In his annotation to **Marâq ul-falâh**, Tahtâwî wrote: "Setting of the Sun means sighting of its upper (following) limb disappear below the line of apparent horizon, not below the true horizon." The Sun's setting below the line of apparent horizon means its setting below the surface horizon. If a person, who has failed to perform the late afternoon prayer, (performs the evening prayer and breaks his fast and then) flies west by plane and sees that the Sun has not set yet (at this place he has newly arrived at), he performs the late afternoon prayer and, after sunset, reperforms (i'âda) the evening prayer and, after the 'Iyd, makes qadâ of his fast. At locations where the apparent sunset cannot be seen because of hills, high buildings and clouds, the time of sunset, as is stated in a hadîth-i sherîf, is the time of darkening of the hilltops in the east. This hadîth-i sherîf shows that **"in the calculation of the time of sunset or sunrise, not the true or apparent altitudes but the shar'î altitudes of the Sun with respect to the shar'î horizon are to be used;"** in other words, the Tamkin must be taken into account. This hadîth-i sherîf should be followed, i.e., the Tamkin should be taken into account in calculating the shar'î times of all the other prayers as well because the true riyâdî times are determined by (a single-step astronomical) calculation. There is a difference of time which is as long as the period of Tamkin between the true and canonical times of a prayer. The Tamkin corresponding to the highest hill of a city cannot be changed. If the period of Tamkin is reduced, late afternoon prayer and the prayers following it being performed before their prescribed time, and, for the same matter, (the worship of) fasting being begun after the end of the time of sahur (imsâk), these acts of worship will not be sahîh (valid). Until the year 1982 no one had considered re-arranging the period of Tamkin in Turkey, and for centuries all Scholars of Islam, Awliyâ', Shaikh al-Islâms, Muftîs and all Muslims had performed all their prayers and started their fastings at their shar'î times. (The calendar prepared and published by the daily newspaper Türkiye gives the correct times of prayers and fasting without making any alterations in the period of Tamkin.)

Calculating the early time of any (of the daily five prayers termed) namâz (or salât) requires a definite knowledge of the Sun's altitude pertaining to the prayer in question. First, the true solar time indicating the difference between midday or midnight and the time when [the center of] the Sun reaches the altitude for the prayer with respect to the true horizon on its path at a location of a certain latitude on a given day with a certain declination of the Sun's center, is calculated. This time is called **fadl-i dâir = difference of time** (represented by the arc GA, The angle H, in Figure 1). To determine the true altitude specific to a certain prayer (namâz), the altitude of the Sun's upper limb with respect to the mathematical horizon is measured with the help of a **(rub'-i-dâira)** or astrolabic quadrant at the moment when the prayer time written in books of Fiqh begins. From this, the true altitude can be calculated. [The apparent altitude with respect to the apparent horizon is measured by using the sextant.] The arc side GK of the spherical triangle KSG imagined on the celestial sphere is the complement of the arc of declination, GD; the curvilinear side KS is the complement of polar distance KF, and the arc SG is the complement of the Sun's true altitude, GN. (Figure 1). The angle H at the polar point K of the triangle, as well as the angular value of the arc GA subtending this angle, represents fadl-i dâir (hour angle); this is calculated in angular degrees and multiplied by four to convert it to true time in minutes. The temporal value of hour angle is combined with the time of true or ghurûbî zawâl or midnight; thereby **true time** of the prayer is obtained in terms of true zawâlî or ghurûbî time. Then the ghurûbî time is converted to adhânî by subtracting one unit of Tamkin from it. The zawâlî time is converted to mean time by adding the equation of time to it. Then the **Shar'î time** of the prayer in question is obtained from these adhânî and mean ghurûbî times. While doing this, the **time of Tamkin**, which is the period between the time when the (upper) limb of the Sun has reached the altitude peculiar to this prayer from the shar'î horizon and the time when the center of the Sun has reached this altitude from the true horizon, is taken into consideration. For, the difference of time between the true and shar'î times of a prayer is equal to the difference of time between the true horizon and the shar'î horizon; this difference is the period of **Tamkin**. The shar'î times are found by subtracting one unit of Tamkin from the calculated true prayer times before midday, since (before midday) the Sun passes the shar'î horizon before passing the true horizon. Examples of this are the times of imsâk and sunrise. Ahmad Ziyâ Beg and Kadûsî say in their books entitled **Rub'-i-dâira**: "Fajr begins when the upper (preceding) limb of the Sun has reached a position 19° below the shar'î horizon. The shar'î time of imsâk in terms of true time is obtained by subtracting Tamkin from the calculated true time of fajr (dawn)." Hasan Shawqi Efendi of Hezargrad, senior professor of Islamic sciences at the Fâtih Madrasa and translator of **Kadûsî'**s **Irtifâ'-i sems risâlesi**, (Booklet on the Sun's Altitude), describes the method of finding the time of imsâk in its ninth chapter, and adds: "The times of true imsâk we have obtained by calculation are without Tamkin. A Muslim who will fast must stop eating 15 minutes, i.e. two units of Tamkin, before this time. Thus, they will protect their fast from being fâsid." As is seen, to find the shar'î adhânî time of imsâk, he subtracts twice the Tamkin from the true ghurûbî time and reports that otherwise the fasting will be nullified. [One unit of Tamkin is subtracted from the ghurûbî time to find the Shar'î time, and another unit of Tamkin is subtracted from the ghurûbî time to convert it to the adhânî time.] This we have observed also in the yearly tables of awqât-i shar'iyya (shar'î times) which Hadrat Ibrâhîm Hakki (of Erzurum) arranged for Erzurum, as well as in the book **Hey'et-i-felekiyya**, by Mustafâ Hilmi Efendi in 1307; therein true times of dawn and sunrise are converted to shar'î times in terms of the system of adhânî time by subtracting twice the period of Tamkin. The same method is applied in the book **Hidâyat-ul-mubtadî fî ma'rifat-il-awqât bi-rub'i-d-dâira** by 'Alî bin 'Uthmân; he passed away in 801 [1398 A.D.]. On the other hand, to find the shar'î prayer times within the period after midday, wherein the Sun transits the shar'î horizon after transiting the true horizon, one unit of Tamkin is added to the true times. In this category are the times of early and late afternoon, evening, ishtibâk, and night. Ahmed Ziyâ Beg states as follows in the aforementioned book, in the chapter dealing with the time of Zuhr: "If Tamkin is added to the time of true zawâl in terms of mean time, the time of shar'î Zuhr in terms of mean time is obtained." Always one unit of Tamkin is subtracted from time known in terms of ghurûbî system of time to convert it to adhânî time. To convert time that is known in respect to the ghurûbî horizons belonging of the period covering noontime and thererafter, to the shar'î time with respect to the shar'î horizons, one unit of Tamkin is added; then one unit of Tamkin is subtracted to convert it to the adhânî time. Consequently, the adhânî times of these prayers concur with their ghurûbî times. The shar'î times determined in terms of haqîqî (true) or ghurûbî systems of time are converted to the wasatî (mean) and adhânî times and printed on calendars. The times determined thereby are riyâdî times in terms of riyâdî time system. The riyâdî times, which are calculated in terms of riyâdî time system, also indicate the mer'î times on clocks.

NOTE: To work out the time of zuhr in terms of adhânî-haqîqî (true) time system from the (already known) ghurûbî-haqîqî time of zawâl, Islamic scholars subtracted the

Tamkin at sunset from it, and they obtained the ghurûbî-zawâl time again by adding the period of Tamkin, which is the method for finding the shar'î time at zawâl. This fact shows that the Tamkin at the time of zuhr must be equal to the difference of time between the true and shar'î horizons, i.e., to the Tamkin at sunset. Likewise, Tamkins for all the shar'î prayer times are equal to those at sunrise and sunset. As is reported in the book **al-Hadâiq alwardiyya**, "Ibni Shâtir 'Alî bin Ibrâhîm [d. 777 (1375 A.D.)] describes in his book **an-Naf'ul'âm** the construction of a quadrant practicable at all latitudes. He devised a basîta (sundial) for the Amawiyya Mosque in Damascus. Muhammad bin Muhammad Hânî (d. 306 h.), a khalîfa (disciple and successor) of Hadrat Mawlânâ Khâlid al-Baghdâdî, renewed it in 1293 [1876 A.D.], and wrote a book entitled **Kashf-ul-qinâ' 'an ma'rifat-il-waqt min-al-irtifâ'.**"

Two other sources that we have studied and wherein the period of Tamkin was taken into account in the calculations of shar'î times of prayers, are a calendar entitled **'Ilmiyye sâlnâmesi** and prepared by **Mashîhat-i Islâmiyya,** the-highest council of the Ottoman 'ulamâ', for the year 1334 [1916 A.D.], and the **Türkiye'ye Mahsûs Evkat-ı Ser'iyye** book no. 14 published by the Kandilli Observatory of the University of Istanbul in 1958. We have seen that the times determined as a result of the observations and calculations carried on by our staff, composed of true men of Islam and specialized astronomers using latest instruments, are the same as those found and reported by Islamic scholars, who used the **rub'-i-daira=astrolabic quadrant,** for centuries. Therefore, it is not permissible to change the quantities of Tamkin, for it would mean to defile the prayer times.

One mean solar day on timepieces is twenty-four hours. A period of twenty-four hours which begins when a time measuring instrument, e.g. our watch, shows twelve o'clock at the haqîqî zawâl time and ends at twelve o'clock the following day is called the **mean solar day.** The lengths of mean solar days are all equal. On the other hand, the duration of time that begins when our watch shows twelve at the time of zawâl and ends at the time of zawâl the following day is called the true **solar day.** The length of a true solar day, which is the time taken by two successive transits of the center of the Sun, is equal to the length of a mean solar day four times in a year. Except on these days, their daily lengths differ by the amount of daily variation in **ta'dîl-i zamân** (equation of time). The length of a **ghurûbî day** is the time between two successive settings of the center of the Sun below the true horizon. An **adhânî day** is the time between two successive canonical settings of the upper [following] limb of the Sun below the canonical horizon of a location. When this (second kind of) setting is observed, the adhânî clock is adjusted to 12. Though an adhanî day is equal in length to a ghurûbî day, it begins a **period of Tamkin** later than a ghurûbî day. Since the Sun culminates only once in a ghurûbî day versus its ascent to and descent from two different altitudes within a true zawâlî day, there is one-or-two minutes difference of length between these two days. The resultant difference of seconds between the horary units of the true zawâlî and ghurûbî times is smoothed out with compensatory modifications manipulated in the period of Tamkin. Timepieces indicate the adhânî or wasatî (mean) times, not the haqîqî (true) or ghurûbî times. Let us set our clock (calibrated to run at the rate of mean time) to 12:00 o'clock at the time of shar'î sunset on any day. The next day, the time of setting of the following limb of the Sun below the shar'î horizon will differ by a little less than one minute from mean solar day, i.e., 24 hours. This alternate difference, which develops against one and the other between the lengths of haqîqî (true) and wasatî (mean) days around (yearly four-time) passing periods of equalization, is termed **equation of time**. Lengths of nights and days have nothing to do with equation of time; nor do ghurûbî or adhânî times. Lengths of days and hours in adhânî hours are equal to lengths of true solar days and hours. For this reason, when timepieces are adjusted to 12 at the time of sunset daily, they indicate the length of true day, not the length of mean day.

Timepieces set to keep the adhânî time must be adjusted to 12:00 at the time of shar'î sunset calculated in mean solar time every evening. Every day, these clocks must be advanced as the time of sunset shifts backwards and taken backwards as it advances. There is not a mean length for an adhânî day, nor a mean equation of time. It is written in the calendar **Mi'yâr-i awqât** prepared in Erzurum in the Hijrî Qamarî year 1193 A.H. (1779): "At the time of true zawâl, when shadows are the shortest, the adhânî clock is taken backwards so as to adjust it to a position one unit of Tamkin behind the time of zuhr written on the calendar." To correct the adhânî clock, when the mean clock comes to a prayer time, the adhânî clock is adjusted to the time of this prayer written on the calendar. A way of adjusting the vasatî and adhânî clocks is as follows: two convergent straight lines are drawn, one in the direction of the observer's meridian and the other towards the Qibla, on a level place. Then, a rod is erected at the point of intersection of these two straight lines. When the shadow of this rod becomes aligned with the line parallel to the meridian the clock is set to the time of zawâl, and when it becomes aligned with the one pointing towards the Qibla, the clock is set to the time of Qibla. The adhânî clock is not adjusted on days with a variation of sunset time less than 1 minute. In Istanbul, clocks are advanced daily throughout a period of six months, so that they are 186 minutes ahead by the end of this period, and thereafter the process is repeated in the opposite direction for another six-month period at the end of which the 186 minutes gradually added to clocks will have been taken back likewise. These clocks reckon time in reference to the beginning of the adhânî day. Calculation of times of namâz, however, is done in reference to the ghurûbî day. Since an adhânî day begins one unit of Tamkin later than a ghurûbî day, prayer times are converted to adhânî time by subtracting the Tamkin from the ghurûbî times determined by calculation. Equation of time is not used in calculating the ghurûbî or adhânî times.

Since the Earth rotates round its axis from west to east, places to the east see the Sun before those to the west. Prayer times are earlier in the east. There are three hundred and sixty imaginary longitudinal semicircles [meridians] passing through the terrestrial poles, and the semicircle passing through Greenwich, London, (termed prime meridian,) has been accepted as the one for reference. There is one degree of angular distance between two successive semicircles. As the Earth rotates, a city goes fifteen degrees eastwards in one hour. Therefore, of two cities one degree of longitude apart from each other but with the same latitude, prayer times for the one on the east are four minutes earlier. Locations on the same meridian, i.e. with the same longitude, have a common time of true zawâl. Times of zawâl and zuhr on the basis of ghurûbî time system, and also other prayer times, depend on latitude. The greater the latitude of a location, the farther away from noon are the times of sunrise and sunset summer, and vice versa in winter. A quantity is measured in reference to a certain beginning; e.g. zero. The more distant something is from zero the greater is it said to be. To start clocks from zero they are adjusted either to zero or to 12 (or 24). The moment at which a certain kind of work is started is said to be the **time** of that work. So is the time of sadaqa-i fitr being wajib. That is, becomes wajib at the moment the fajr (dawn) breaks on the first day of 'iyd-i fitr. It becomes wajib for a person who becomes a Believer or is born an hour before, or to those who die an hour later. Not to those who become Believers or who are born an hour later. The time here may mean as short as a moment or a long period. In the latter case, the time has a beginning and an end. Examples of the latter case are the **time of shar'î zawâl**, **prayer times**, and the time during which it is **wâjib to perform the Qurbân**.

Clocks adjusted to local (mahallî) times in cities to the east are ahead of those adjusted to the local times in cities to the west on the same day. The time of zuhr, i.e., the shar'î time of early afternoon prayer begins a period of Tamkin later than true zawâl time at every location. Since the adjustments of local clocks vary in direct ratio to their longitudinal degrees, the prayer times on local clocks on the same latitude do not vary with longitudinal variations. The adhânî time clocks are local today, as they were formerly. Since the highest places of different locations are not equal in height, the period of Tamkin applied at different locations differ from one another by about one or two minutes, and so do the shar'î times of (daily five) prayers; yet the precautionary modifications made in Tamkin eliminate such differences. In the present time, clocks adjusted simultaneously to a common mean time in all cities of a country are used. In a country where this **common (standard)** mean time is used, time of a certain prayer in standard mean time vary even in cities on the same latitude. Four times the longitudinal difference between a pair of cities with the same latitude shows the difference, in minutes, between the times of the same prayer, in standard mean time, in these two cities. In brief, at locations on the same longitude, the only two things that remain unchanged despite change of latitude are clocks adjusted to local time and those adjusted to Standard mean time. As the absolute value of latitude increases, a prayer time moves forwards or backwards, the direction depending on the time's being before or after noon as well as on the season's being summer or winter. Calculation of prayer times from those for the latitude 41° N has been explained in the instructions manual for the **Rub'-i-dâira** (in Turkish). When longitudinal degrees change, i.e. at places with common latitude, the adjustments of timepieces and all the prayer times on the standard timepieces change.

In all places between the two longitudes 7.5° east and west of (the longitude of Greenwich,) London, mean solar time for London (Greenwich Mean Time, GMT, or Universal Time, UT, counted from midnight,) is used. This is called the West European Time. In places between seven and a half degrees and twenty-two and a half degrees east of London, time one hour ahead of it is used, which is called Central European Time. And in places between 22.5° and 37.5° of longitude east, time two hours ahead of GMT is used, which is called East European Time. Times three, four and five hours ahead of GMT are used in the Near, Middle and Far East, respectively. There are twenty-four such zones of standard time on the Earth, which follow one another by one hour. The **standart time zone** adopted in a country is the one centered on the mean local time of places located on one of the **hourly longitudinal semicircles** imagined to traverse the country with intervals of fifteen degrees. Turkey's standard time zone is the local mean time of the places located on the meridian thirty degrees east of London, which is East European Time. The cities Izmit, Kütahya, Bilecik and Elmalı lie on the meridian 30°. Some countries do not use the time of the geographical zone they are in because of political and economic considerations. For example, France and Spain use the Central European Time. Clocks in countries where different standard times are used are so adjusted as to differ from one another only by multiples of hours at any given moment; the hourhand in a country is in advance of that in one to its west.

The time of a prayer at a given place in Turkey in local solar mean time differs, in minutes, from Turkey's standard time by four times the longitudinal difference between that place and the longitude 30°. To find the time of this prayer in standard time, this difference will be subtracted from or added to the local time if the longitudinal degree of that place is greater or smaller than 30°, respectively. For example, let us say the time of a prayer begins in the city of Kars (41°N, 43°E) at 7 hr 00 minutes in local mean time on May 1. The city's longitude being 43°, which is greater than 30°, local time of Kars is ahead of standard time. Then the time of that prayer begins 13 x 4 = 52 minutes earlier, at 06:08 in standard time.

The sum of $\mathbf{M_g}$ (the time of zawâl in ghurûbî time) and $\mathbf{S_t}$ (the time of true sunset in true solar time) for the same place is equal to 12 hours [equation (1), below], because this sum is a period of about 12 true hours continuing from 12 o'clock in the morning in ghurûbî time to the time of true sunset. Please see the chart for summer months. The unit of true solar time is approximately equal to that of ghurûbî time.

Time of midday (Zawâl) in ghurûbî time+Time of sunset in true time = 12hours or

$$\mathbf{M_g + S_t = 12\ hours} \qquad \mathbf{(1)}$$

The sum of half of true daytime and half of true night-time $\mathbf{N_t}$ is about 12 hours. Therefore,

Half of true night-time + Time of sunset in true time = 12hours or
$1/2\ N_t + S_t = 12$ hours **(2)**

By combining the equations (1) and (2), we obtain:

Time of midday (Zawâl) in ghurûbî time=Half of true night-time or
$M_g = (1\ /\ 2)\ N_t$ **(3)**

The time of midday in ghurûbî time is from the ghurûbî twelve in the morning till true midday. The ghurûbî twelve in the morning is half the daytime later than midnight. It is before sunrise in winter, and after sunrise in summer. The period for morning prayer, as well as that for fasting, begins at the time of fajr-i-sâdiq. Its beginning is known when the adhânî clock, which begins from 12 at the time of sunset, indicates the time of fajr, or when the mean clock, which begins from 12 at the time of midnight, indicates the time of fajr. Sunrise begins half the night-time later than 12 midnight, or a period of night-time later than 12 at the time of sunset, or half the daytime earlier than zawâl. Twelve o'clock in the Ghurûbî morning is 12 hours after 12 at the time of sunset, or half the daytime later than 12 midnight, or half the night time earlier than time of true zawâl. Between the time of sunrise and (the ghurûbî) 12 in the morning there is a difference equal to the difference between halves the lengths of night and day. All these calculations are done using the true solar time. After calculation, true solar time is converted to mean solar time and thence to standard time. Below, we shall see that the time of midday in ghurûbî time is the time of zuhr in adhânî time. For that matter, on May 1, since the time of zuhr in adhânî time is 5:06, the time of shar'î sunrise in standard time in Istanbul is 4:57 (5:57 in summer time).

If days and nights were always equal in length, the Sun would always rise six hours before midday and set six hours thereafter. Since they are not equal, the period between the times of zawâl and ghurûb (sunset) is somewhat longer than six hours in summer months. In winter months, on the other hand, this period becomes a little shorter. This discrepancy centered around the mean six hours is called the **nisf fadla = excess of semi-diurnal** time. (Please see Figure 2). In summer months, true sunsets differ from the time of zawâl by the sum of six and nisf fadla, whereas their difference in winter months is the subtraction of nisf fadla from six. Conversely, the ghurûbî twelve in the morning is transpositionally the same amount different from the time of zawâl.

To find the time of zuhr in adhânî time system and the times of sunrise and sunset in true and mean time systems, the nisf fadla is obtained by using Scottish Mathematician John Napier's formula. According to this formula, on a spherical right triangle [for example, the triangle TCL in Figure 2] cos of one of the five parts other than the right angle [sin of its complement] is equal to the product of cot values of the two parts adjacent to that part [tan of their complements], or to the product of the sin values of the other two parts not adjacent to it. However, instead of the (angles subtended by the) two perpendicular sides themselves, their complements are included in the calculation. So,

sin (nisf fadla) = tan (declination) x tan (latitude).

Using this formula and with the help of a scientific calculator or a table of logarithms of trigonometric functions, the arc of **nisf fadla** in degrees and, multiplying this by 4, its equivalent in minutes of true solar time are found. If the terrestrial location of a certain city and the celestial position of the Sun are on the same hemisphere, (so that the latitudinal value of the former and the declinational value of the latter share the same sign,) its local solar time of true sunset is obtained by adding the absolute value of nisf fadla to 6 true solar hours (one-fourth of a true day). By subtracting the absolute value of nisf fadla from 6 hours, the time of true midday (zawâl) in ghurûbî time, or the time of true sunrise in true solar time, [beginning with midnight,] is found. That means to say that the ghurûbî 12 in the morning is earlier than the time of true zawâl by the difference obtained by doing this subtraction. **Please click here for the table of declination of the Sun.** If the city in question and the Sun are on different hemispheres, the time of true zawâl in ghurûbî time, or the time of true sunrise in true solar time, is obtained by adding the absolute value of nisf fadla to 6 hours; and by subtracting nisf fadla from 6 hours the time of true sunset in true solar time is obtained for that city.

For instance, on May 1, declination of the Sun is +14°55', equation of time is +3 temporal minutes and Istanbul’s latitude is +41°; depressing the keys,
14.55 tan x 41 tan = arc sin x 4 =

on the scientific calculator (Privilege) gives the resultant 53min 33sec (of time). Nisf fadla is found to be 54min (of time); the calculated true sunset is at 6:54 in true zawâlî time, at 6:51 in local mean zawâlî time, and at 18:55 in standard time or at 19:55 in summer time. Time of canonical sunset is found to be 20:05, in summer time, by adding the Tamkin of 10 minutes for Istanbul. Duration of true daytime is 13 hours plus 48 minutes, and duration of night is its difference from 24 hours, i.e. 10 hours plus 12 minutes; 5:06, which is the difference between nisf fadla and 6 hours, is the time of true sunrise in true time, i.e. from the time of midnight, or the time of zawâl in terms of ghurûbî time. The time of true midday in adhânî time is earlier than that in ghurûbî time by a period of Tamkin; i.e., it is at 4:56. The shar’î time of zuhr in adhânî time begins later than the time of true midday in adhânî time by a period of Tamkin, that is, at 5:06. Twice the time of zuhr in adhânî time, 10 hours and 12 minutes, is the approximate duration of astronomical nighttime, and subtracting 20 minutes (twice the Tamkin) from this gives 9:52 to be the time of shar’î sunrise in adhânî time. If equation of time and Tamkin are subtracted from 5 hours 6 minutes and the result is converted to standard time, the time of shar’î sunset is obtained to be 4:57. Subtraction of the time of adhânî zuhr from 6 hours yields the nisf fadla time. Since the maximum absolute declination of the Sun is 23° 27', the Nisf fadla is 22° maximum by calculation for Istanbul, which makes one hour and twenty-eight minutes, and hence there is a difference of 176 minutes between the latest and earliest times of sunset. And since there is equal difference between the (earliest and latest) times of sunrise, the difference also between the longest and shortest daytimes is 352 minutes, [5 hours and 52 minutes.]

Nisf fadla is zero, always at locations on the equator, and all over the world on March 21st and on September 23rd, because the declination of the Sun, and hence tan. dec., is zero always on the equator and worldover on March 21st and on September 23rd. On April 1, declination of the Sun is 4°20' and the equation of time is -4 minutes. The latitude of Vienna, Austria, is 48°15', and nisf fadla is found, with the use of a scientific (Privilege) calculator by depressing the keys, CE/C 4.20 tan x 48.15 tan = arc sin x 4= to be about 19.5 minutes. Then, the time of the evening prayer [shar’î sunset] in Vienna begins at 6:33:30 in local mean solar time. Vienna’s longitude is 16°25', which is 1°25' east of the (hourly) standard meridian; therefore, the time of evening prayer begins at 6:27:30 in Austria’s geographical standard time, which is 1 hour ahead of GMT. Since the latitude of Paris is 48°50', nisf fadla is 20 minutes and the time of the evening prayer in local mean time begins at 6:34; with its longitude +2°20' east, it should normally begin at 6:25 in the geographical standard time, yet the standard time used in France is 1 hour ahead of West European Time; so it begins at 19:25. As for New York; its latitude is 41°, and nisf fadla is 15 minutes; hence the time of evening prayer begins at 6:29 in local mean time; with longitude -74°, it is 1° east of the (hourly) standard meridian -75° which corresponds to the standard geographical time 75÷15=5 hours behind that of London; therefore, evening prayer begins at 6:25 in that time zone. For Delhi, latitude is 28°38'; nisf fadla is 9.5 minutes, the time of evening prayer begins at 6:23:30 in local mean time; its longitude is +77°13'. Since this longitude is 5°17' west of the India’s common meridian, which in turn is 5,5 hours ahead of London, the time of evening prayer begins at 6:44:30 on the common meridian.

For Trabzon, latitude is the same (41°) as that for Istanbul, and longitude is 39°50'. To find nisf fadla on May 1, the following keys of the CASIO fx-3600P scientific calculator are depressed:

ON 14 ° ' '' 55 ° ' '' tan x 41 tan = INV sin x 4 = INV ° ' '' and the time of nisf fadla is found to be 53 minutes and 33 seconds, which is about 54 minutes. Time of sunset, like in Istanbul, is 7:01 in local mean time, and 39 minutes earlier, i.e. 6:22, in standard time. Al-Mekkat al-mukarrama is on latitude 21°26' and, like Trabzon, on longitude 39°50', and nisf fadla on May 1 is 24 minutes. Time of sunset is 6:31 in local mean time, and 5:52 in standard time, which is 39 minutes before this as adjusted to the standard meridian of longitude 30°. On November 1, declination is -14°16' and the equation of time is +16 minutes. Nisf fadla is 51 and 23 minutes for Istanbul and Mekka, respectively, while the time of sunset in standard time is 5:07 and 4:52 for Istanbul and Mekka, respectively. On November 1, adhân for evening prayer can be heard from a local radio broadcast in Mekka 15 minutes before the same adhân in Istanbul. In the above calculations for sunset at various cities, the Tamkin for Istanbul is used. On the clocks set to adhânî and local mean times in different cities on a common latitude, prayer times differ only by the difference in the periods of Tamkin applied in them.

The time of zawâl in local mean solar time differs from 12 hours (in local true solar time) by the equation of time, i.e. less than one minute, everywhere, and annually ranges, e.g. in Istanbul, from approximately 16 minutes before to 14 minutes after 12. In standard time, however, it is earlier or later than the local time of the place by an amount, in minutes, of four times the longitudinal difference between the place in question and the standard meridian of longitude 30° for every location in Turkey. And the time of zawâl changes every day for an amount of one or two minutes on the adhânî clocks. The Ottoman administration employed **muwaqqits** (time-keepers), who were in charge of these adjustments in great mosques.

An easy way to determine the equation of time on a certain day is simply to learn the time of early afternoon prayer [zuhr] in terms of standard time on that day in a certain city, e.g. in Istanbul. This time minus 14 minutes is the time of midday in local mean solar time. As the time of midday in true solar time is 12 o’clock everywhere, the difference between these two midday times in minutes is the equation of time. If the time of zawâl (midday) in mean time is short of 12:00, the sign of the equation of time is (+) and, if it exceeds it, it is (-).

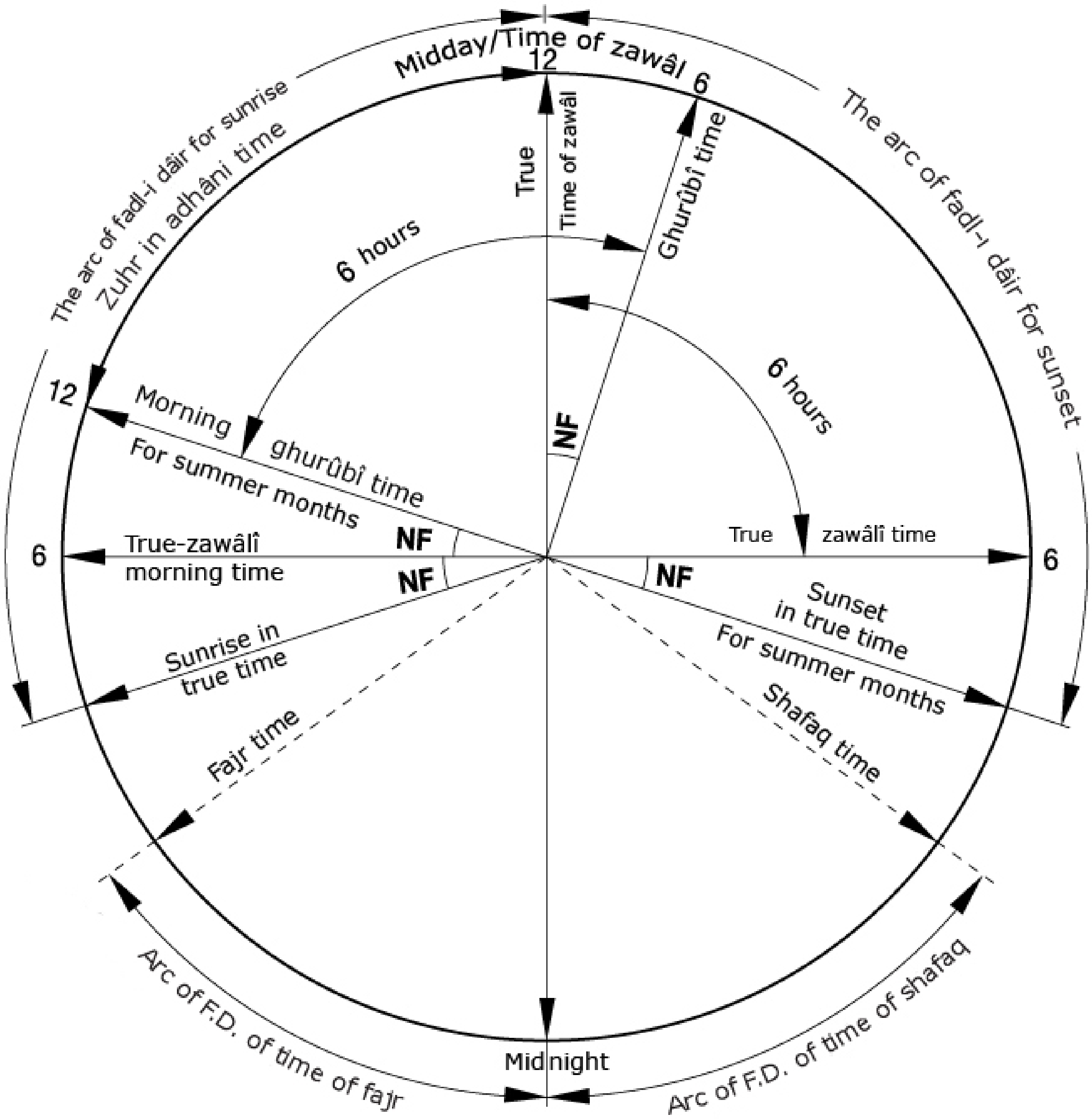

Figure 3

F.D. = Fadl-ı dâir=Hour Angle.
NF=Nısf fadla angle=Excess of Semi-diurnal arc (Conversely, complement of semi-nocturnal arc)

Note: In 6 + (NF), the NF is to be substituted algebraically. Nf is (+) in summer and (-) in winter.

Since the equation of time is -13 minutes on March 1, a place's local time of zawâl in terms of mean solar time is 12:13 everywhere. The time of early afternoon prayer begins later than this by the amount of Tamkin. In Istanbul, for example, it begins at 12:23. At any location, its time in terms of standard time begins either earlier or later than its time in terms of local mean time by an amount, in minutes, equal to four times the longitudinal difference in degrees between the (hourly) standard meridian and the meridian of the place in question. If a location in Turkey is to the east of the standard meridian 30° E, it is earlier, otherwise later. Thus, the time of early afternoon prayer in terms of standard time is about 12:11 in Ankara, whereas it is 12:27 in Istanbul. When a clock adjusted to standard time arrives at the time of early afternoon prayer, the daily adjustment of a clock keeping the adhânî time would have been realized simply by setting it to the time of the early afternoon prayer determined by using the nisf fadla. If the height of the highest place is not known, the **period of Tamkin** of a location is either (1) the period between the moment when sunlight reflected on the highest place disappears and the instant when sunset below the tangential horizon is observed, or (2) the difference between 12 and the time found by combining with equation of time the time shown by a clock set to local mean time when it is the time of zuhr determined by applying nisf fadla to the time shown on an adhânî clock set to 12 when sunlight reflected on the highest place of the location is observed to disappear, or (3) the difference between the time when the reflection of sunlight on the highest place disappears in terms of local mean time and the time of sunset determined by applying nisf fadla; or (4) the period of time determined by adding the equation of time to the difference of time of zuhr in local mean time and 12:00 if the equation of time is positive (+), or by subtracting it if it is negative (-).

It is written as follows in Ibn Âbidîn, as well as in the Shâfi'î book **al-Anwâr** and in the commentary to the Mâlikî book **al-Muqaddamat al-izziyya,** and also in **al-Mîzân ul-kubrâ**: "For a salât (prayer) to be sahîh (valid), one should perform it after its time has begun and know that one is performing it in its correct time. A salât performed with doubtful knowledge as to the arrival of its correct time is not valid (sahîh) even if you realize, after performing it, that you performed it in its correct time. To know that the prayer time has come means to hear the adhân recited by an 'âdil Muslim who knows the prayer times. If the reciter of the adhân is not 'âdil [or if there is not a calendar prepared by an 'âdil Muslim], you should investigate whether the time has come and perform it when you surely believe that it is the time. Information obtained from a fâsiq Muslim or a person who is not known to be an 'âdil Muslim concerning the direction of qibla or other religious matters such as cleanliness or uncleanliness of something, or whether a certain act (or behaviour or thought) is halâl (permitted) or harâm (forbidden), as well as the (call to prayer termed) adhân performed by such a person, is not trustworthy; instead of asking a person of that kind, you have to learn the matter in your own and act in accordance with the result of your personal research."

It is mustahab to perform the morning prayer when it becomes rather light everywhere in every season; this is called **"isfâr"**. It is mustahab to perform the early afternoon prayer in jamâ'a late on hot days in summer and early on winter days. It is mustahab to always perform the evening prayer early. And it is mustahab to perform the night prayer late but till it is the initial one-third of the shar'î night, which is the period of time between ghurûb (sunset) and fajr (dawn). It is makrûh tahrîmî to postpone it till after midnight. In fact, the postponements suggested above apply only to those who perform namâz in jamâ'a. A Muslim who performs namâz alone at home should perform every prayer as soon as its time begins. A hadîth sherîf reported in **Kunûz ad-daqâ'iq** on the authority of Hâkim and Tirmidhî reads: **"The most valuable 'ibâda is the salât performed in its early time."** Another hadîth sherîf, reported in the **Sahîh of Muslim** and also written on page 537 of **Izâlat al-khafâ**, declares: **"Such a time will come when directors and imâms will kill the salât;** [that is,] **they will postpone it till the expiration of its** [prescribed] **time. You should perform your salât within its time! If they perform it in jamâ'a after you** [have performed it], **perform it again together with them! The one you perform the second time is nâfila** (supererogatory).**"** It would be cautious to perform the late afternoon and night prayers according to Al-Imâm al-a'zam's ijtihâd. A Muslim who is afraid he may fail to wake up later should perform the witr prayer immediately after the night prayer. He who performs it before night prayer should reperform it. And he who can wake up should perform it towards the end of the night.

Ahmad Ziyâ Beg provides the following information on page 157: In a city, the algebraic sum of a certain prayer's canonical time known with respect to the local mean time and the equation of time for the day in question is its time with respect to the true solar time. This plus the time of zuhr in adhânî time and minus one unit of Tamkin yields the prayer’s shar’î time with respect to the adhânî time. If the result exceeds twelve, the excess indicates the adhânî time. For example, the Sun sets at 18:00 (6:00 p.m.) in standard time in Istanbul on March 1. Since the equation of time at the time of sunset is -12 minutes, the time of shar’î sunset in Istanbul is 5:44 in local true solar time. And since the time of shar’î zuhr in adhânî time is 06:26, the time of sunset is 06:26+05:44-00:10=12:00. In general,

(1) t in adhânî time = t at the same moment in true solar time + t of zuhr in adhânî time - Tamkin of the location

(2) t in true solar time = t in adhânî time + t of shar’î sunset in true solar time

where **t** is time.

In the equation (2), if the time of sunset is in mean time, the zawâlî time obtained is also mean.

The equation (2) may also be written as:

(3) t in adhânî time = t in true solar time - t of shar’î sunset in true solar time

If the time of sunset treated is greater than the true time, the subtraction must be done after twelve is added to the true time.

The zawâlî time in the equations (2) and (3) is given in true solar time; yet, since the same numbers are added and then subtracted while converting standard time to true time and then the true time found to standard time, the computation done without converting standard time to true time yields the same results; as follows:

(4) t in standard time = t in adhânî time + t of shar’î sunset in standard time

(5) t in adhânî time = t in standard time - t of shar’î sunset in standard time

The time of sunset on March 1 as calculated above can also be determined with the help of the last equation: 18:00 - 18:00 = 00:00, which is 12:00 in adhânî time. Likewise, since the time of the late afternoon prayer is 15:34 and the time of sunset is 6:00 in standard time on March 1, the time of the late afternoon prayer in adhânî time is:

15:34 - 6:00 = 9:34.

Similarly, since the time of imsâk in adhânî time on the same day is 10:52, the time of imsâk in standard time is 10:52+6:00=16:52 or 4:52 p.m. by the equation (4).

Let us find the time of sunset in true solar time in Istanbul on 23 June 1982 Wednesday, 1 Ramadan 1402: on that day, the time of the early afternoon prayer in Istanbul is 4:32 in adhânî time, and the equation of time is -2 minutes. The time of sunset in local true solar time in Istanbul is the difference between this and 12 hours; that is, 7:28. The shar’î sunset is at 7:38 in true solar time, at 19:40 in mean solar time, at 19:44 in standard time of Türkey and at 20:44 in summer time.

If the time in standard time is smaller than the time of sunset, 12 or 24 is added to it in the equations (3) and (5). Ahmad Ziyâ Beg employs the formulas

(6) t in adhânî time = true time of zawâl + true solar time

and

(7) true solar time = adhânî time-true time of zawâl.

Mustafa Efendi, Chairman of the Ottoman Astronomy Department, wrote in the pocket calendar of 1317 A.H. (1899): “In order to convert ghurûbî and zawâlî times to each other, the time given in one is subtracted from the time of early afternoon prayer if the time in question is before noon (a.m.); then this difference is subtracted from the time of early afternoon prayer in the other time. If it is p.m., the time of early afternoon prayer is subtracted from the time given, and then the difference is added to the time of early afternoon prayer in the other time. For example, the time of imsâk on June 12th, 1989 is 6:22 in adhânî time; the time of zuhr is 4:32. The difference (16:32-6:22)=10:10. Subtracting this from 12:14, which is the time of the early afternoon prayer in standard time, the time of imsâk is found to be 2:04 in standard time.

To determine the time the Sun comes to the altitude for the beginning of the time of a certain salât, first the value of **fadl-i dâir** (time corresponding to the hour angle of the Sun) is calculated. Fadl-i dâir is the interval between the point where the center of the Sun is and the time of zawâl (midday) for the daytime, and it is the interval between that point and midnight for the nighttime. The angle of fadl-i dâir, H, can be calculated from the formula for the spherical triangle: [See Figure: 1]

$$\sin\frac{H}{2} = \sqrt{\frac{\sin(M - 90° + \delta) \times \sin(M - 90° + \varphi)}{\sin(90° - \delta) \times \sin(90° - \varphi)}} \qquad (1)$$

where δ is the declination of the Sun and φ is the latitude of the location and M is the half of the sum of the three sides of the spherical triangle and determined with the formula:

$$M = \frac{(90° - \delta) + (90° - \varphi) + (90° - h)}{2}$$

where h is the altitude of the Sun. The sign of altitude is (+) above the true horizon and (-) below it. If declination and altitude have opposite signs, the declination added to 90°, instead of its complementary to 90°, is taken.

The formula for fadl-i dâir is simplified by substituting the value of M as

$$\sin\frac{H}{2} = \sqrt{\frac{\sin\frac{Z + \Delta}{2} \times \sin\frac{Z - \Delta}{2}}{\cos\varphi \times \cos\delta}} \qquad (2)$$

Here, the interval represented by the angle H is measured in reference to the meridian (nisf-un-nahâr), and:

Δ = 90° - **GI** = (latitude of location) - (declination of the Sun) = $\varphi - \delta$,
where **GI** is the acronym of **ghâyat irtifa’, which in turn is the maximum altitude of the Sun’s centre** (at midday).

Z (angular distance from the zenith) = 90° - (azimuthal zenith), which represents the angle of **Fay-i zawâl** formed by the two straight lines which start from the top of the rod, each extending in the direction of one of the two celestial points, which are the point of culmination and that of azimuthal zenith. The variables are substituted into the formula with their algebraic signs.

Let us calculate the time of ’asr awwal, i.e. the early time of late afternoon prayer in Istanbul on August 13. Assuming that a rod of 1 m in length is erected on the ground: [The two acute angles of a right triangle are complementary to each other. If one of the sides inscribing an angle is 1 cm. in length, its tangent shows the length of the side subtending it. The Sun’s acute angle **(SAA)** on the ground, (i.e. the angle formed by the rod’s shadow on the ground and subtended by the rod,) is the Sun’s altitude.]

tan Z_1 = tan (90° -h_1) = 1 + fay-i zawâl = SAA

where Z_1 represents the angle complementary to the altitude h_1 for ’asr awwal, **SAA** is the the length of [the rod’s] shadow at ’asr awwal, and

fay-i zawâl = tan (90° - GI) = tan Δ

where (90° - GI) is the angle complementary to ghâyat irtifâ’ (altitude of the centre of the Sun at midday). **Ghâyat irtifâ’, GI = maximum altitude** of the Sun at the time of zawâl is determined by adding the declination to the angle complementary to latitude if the signs of both are the same, i.e., when both of them are on the same hemisphere, or by subtracting the declination from the latter if they have opposite signs, i.e., when they are on different hemispheres. If the sum of the angle complementary to latitude and declination is more than 90°, its difference from 90° is the GI, and the Sun is in the eastern side of the sky. If latitude and declination are on the same side, their difference or, if they are on different sides, their sum gives the complementary to GI (Δ).

GI = 49°00' + 14°50' = 63°50'

log (fay-i zawâl) = log tan (26°10') = $\bar{1}.69138$

Fay-i zawâl = 0.4913 metres,

tan Z_1 = tan (90° -h_1) = 1.4913 and using the table of logarithms of trigonometric functions,

log tan Z_1 = 0.17357

or with a Privilege calculator, the operations:

1. 4913 arc tan  give:

90° - h_1 = bu’d-i semt (azimuthal distance) = Z_1 = 56°09'.

$$\mathrm{M} = \frac{75^\circ\,10' + 49^\circ + 56^\circ\,09'}{2} = 90^\circ\,10'$$

$$\sin\frac{\mathrm{H}}{2} = \sqrt{\frac{\sin 15^\circ \times \sin 41^\circ\,10'}{\sin 75^\circ\,10' \times \sin 49^\circ}}$$

and using the table of logarithms of trigonometric functions,

$$\log\sin\frac{\mathrm{H}}{2} = \frac{1}{2}[(\bar{1}.41300 + \bar{1}.81839) - (\bar{1}.98528 + \bar{1}.87778)]$$
$$= \frac{1}{2}(\bar{1}.23139 - \bar{1}.86306) = \frac{1}{2}(\bar{1}.36833) = \bar{1}.68417$$

(1/2) H=28°54' and H=57°48' and multiplying this by 4 we get 231.2 minutes of time, that is, 3 hours 51 minutes, which is the period of fadl-i dâir (hour angle) for the ’asr awwal on August 13th in Istanbul. Since the true time is 00:00 at the time of true zawâl, it is directly the time of true ’asr awwal in true time and is three hours and fifty-one minutes, which is equal to the time for the rod’s shadow to lengthen by a length equal to its height after the time of true zuhr. Shar’î time of ’asr awwal in reference to shar’î zuhr is later than this by the amount of the Tamkin of that location. Since equation of time is -5 minutes, it is 16:10 in standard mean time. If the time of sunset in standard mean time, 7:12, is subtracted from this standard mean time, time for the late afternoon prayer in Istanbul is obtained in adhânî time to be 8:58, using equation (5) a few pages earlier. When the (time termed) fadl-i-dâir is added to the adhânî time of zuhr, i.e. the true time of zawâl with respect to the ghurûbî time, which is five hours and seven minutes, the result is both the true time of late afternoon prayer in ghurûbî time and the shar'î time of 'asr-i-awwal in adhânî time. For, although the shar'î time of 'asr-i-awwal is one unit of Tamkin later than this sum, i.e., than the ghurûbî true time, its shar'î time in adhânî time is one unit of Tamkin earlier than that ghurûbî shar'î time. Similarly, the shar'î times of early afternoon, evening and night prayers in adhânî time are the same as their true times found by calculation in ghurûbî time.

Another method applicable for determining the altitude for the 'asr-i-awwal (the early time for late afternoon prayer) is as follows: the time when the Sun reaches maximum altitude, (i.e. its culmination,) is determined graphically by measuring or calculating, the length of the shadow of a 1 m long (vertical) rod (erected on a level ground); the maximum altitude and the length of the shadow are recorded daily. Hence, a table of (altitude versus shadow length) is obtained. Since the maximum altitude of the Sun is 64° on August 13, the minimum length of shadow is 0.49 m as can be read off from the table. The length of the shadow is 1.49 m and the altitude is 34°. A table of altitude versus length of shadow exists in the appendix of the book **Taqwîm-i sâl** printed in 1924. (Please click to see Sun's Altitudes at Time of Late Afternoon Prayer for Any Latitude)

The 'asr thânî time of early afternoon prayer (, i.e. the later time for late afternoon prayer,) can be found by utilizing the same formula, yet in this case:

tan Z_2 = tan (temâm-i irtifâ'i şems) = 2 + fay-i zawâl = SAT

where **Z_2** is the angle complementary to the Sun's altitude for 'asr thânî = azimuthal distance, and **SAT** is the [length of the gnomon's] shadow at 'asr thânî.

temâm-i irtifâ = bu'd-i semt **=** Z_2 = 68° 08'. Hence.

M = 96°09' and

H= 73° 43'.

The time of fadl-i dâir is 4 hours 55 minutes. When the Tamkin is added to this, the 'asr thânî comes out to be 5:05 for Istanbul in true solar time.

To determine the time of the 'asr-i-awwal for late afternoon prayer, first the angle Z, complementary to altitude h, and then fadl-i dâir are calculated using the formulas:

Z_1 = complementary to the Sun's altitude (bu'd-i semt = azimuthal distance) = arc tan (1 + tan Δ),

and for the 'asr-i-thânî:

Z_2 = complementary to the Sun's altitude (bu'd-i semt = azimuthal distance) = arc tan (2 + tan Δ),

where tan Δ is fay-i zawâl. The angle whose tangent is equal to the sum of tan Δ and 1 or 2 is the value of Z_1 and Z_2, respectively, (complementary to the altitude) for late afternoon prayer.

At the 'ishâ awwal of night prayer, the center of the Sun is 17° below the true horizon; in other words, its true altitude is -17°. Since the declination plus 90° is taken into account instead of the angle complementary to the declination:

$$\mathrm{M} = \frac{104°\ 50' + 49° + 73°}{2} = 113°\ 25' \text{ and } \mathrm{H} = 50°\ 53'$$

and the time of fadl-i dâir = hour angle is 3 hours 24 minutes, which is the interval from the time for night prayer in true time to midnight. 10 minutes of Tamkin at the time of

’ishâ for Istanbul is added to the difference between that time [of fadl-i dâir] and 12 hours, since the center of the Sun leaves the shar’î horizon later and naturally its following limb leaves the horizons even later. On August 13, the time for the night prayer is 8:46 in true solar time and 20:55 in standard time. Subtracting the time of fadl-i dâir from the time of adhânî zuhr, which is equal to half the true night-time, one unit of Tamkin is added to it to find the ghurûbî time, which is then converted to adhânî time by subtracting one unit of Tamkin from it. Or, instead of first adding and then subtracting the Tamkin, the time of shar’î ’ishâ awwal in terms of ghurûbî and adhânî times is found to be 1:42, without taking the Tamkin into account.

On August 13, as the whiteness called fajr-i sâdiq begins to dawn, the center of the Sun is below the true horizon by the sum of 19° and the angle of the Sun’s altitude; in other words, the Sun’s true altitude exceeds -19°. Hence:

$$\mathrm{M} = \frac{104°\ 50' + 49° + 71°}{2} = 112°\ 25' \text{ and } \mathrm{H} = 47°\ 26'$$

and dividing this by 15, we get the time of fadl-i dâir (hour angle) to be 3 hours 10 minutes, which is the distance between the Sun’s center and midnight. This is the **time of imsâk** in true time since the true time is 00:00 at midnight. The Tamkin, 10 minutes, is subtracted from this, because the Sun’s altitude of -19° is closer to the shar’î horizon than it is to the true horizon and naturally the upper (preceding) limb of the Sun is closer than its center to the horizons. Then, the time of imsâk is 3:00 in true solar time of Istanbul and 3:09 in standard time. If fadl-i dâir is added to the time of zuhr, i.e. (5:07), which is equal to half of the night-time, and then 20 minutes of Tamkin is subtracted, the time of imsâk comes out to be 7:57 in adhânî time. The fadl-i dâir found on the programmable CASIO fx-3600P calculator is 8 hours 50 minutes, which is the interval from the fajr (dawn) to the zawâl (midday). To find its difference from midnight, this is subtracted from 12 hours, which yields fadl-i dâir to be 3 hours 10 minutes, again.

The period between dawn and sunrise is called **hissa-i fajr = duration of dawn**, that between dusk and sunset is called **hissa-i shafaq = duration of dusk**. If the fadl-i dâir of dawn or dusk is subtracted from the adhânî zuhr time, [i.e., from midnight,] or if nisf fadla is added (in winter) to or subtracted (in summer) from the complementary to the fadl-i dâir of dawn or dusk, their conversions to time will yield the hissas = durations. Since the signs of the altitudes for fajr and shafaq are (-), their fadl-i dâirs begin from midnight.

Ahmad Ziyâ Beg wrote: “The ’ulamâ’ of Islam reported the time of imsâk to be the time of the first sighting of whiteness on the horizon, not the time when it spreads around it.” Some European books, however, define the time of dawn as the time when the spread of redness, which begins later than whiteness, along the horizon is completed, thus taking into account the true altitude of the Sun 16° below the horizon. As it has been observed since 1983, some people who publish calendars act under the guidance of those European books and base their calculations of the time of imsâk on the solar position 16° below the horizon. Muslims who begin fasting according to such calendars continue eating sahûr meal till 15 to 20 minutes after the deadlines prescribed by the Islamic scholars. Their fast is not sahîh. On the first and last pages of the pocket calendar **Takwîm-i Ziyâ** for 1926 (Hijrî lunar 1344, solar 1305) by Ahmad Ziyâ Beg, it is stated: “This calendar has been printed after the examination carried out by the Board of Consultation and a certification granted under the authority of the Great Head Office of the Religious Affairs.” Prayer times approved by a Board composed of eminent Islamic scholars aided technically by an expert astronomer should not be altered. Some details on this topic have been provided by Elmalılı Hamdi Yazır in the twenty-second volume of the magazine **Sabîl-ur-reshâd**.

Because the Sun’s declination changes every moment, its hourly declination should be used in order to obtain accurate results.

For example, let us examine the accuracy of our clock in the afternoon on May 4, in Istanbul. The Sun’s declination is +15°49' at 00:00 London time, i.e., at the beginning of the day (the pervious midnight). In Istanbul, with the help of the instrument called **“astrolabic quadrant”,** apparent altitude of the Sun’s upper limb with respect to mathematical horizon is measured and, by subtracting the value of the atmospheric refraction of light for this altitude and 16' for the radius of the Sun, true altitude of the Sun’s center with respect to true horizon is obtained. We write down the standard zawâlî time of our clock, say, 2:38 pm, at the moment the true altitude is measured, say, +49°10'. Declination of the Sun is +16°06' on May 5. The difference in declination is 17' for 24 hours. Since our clock is 2 hours 38 minutes ahead of the time of zawâl (midday) while the mean solar time in London is 1 hour 56 minutes slower than that in Istanbul, the interval from midnight in London to the time we measure the altitude in Istanbul is 12:00+2:38-1:56=12:42=12.7 hours. The difference in declination for this interval is (17/24)x12.7=9'. Differences of declination must be added to the calculation in determining the prayer times. Accordingly the declination becomes +15°58', since it is on the increase in May.

There is another formula, more suitable to scientific calculators, for finding the angle of fadl-i dâir, the hour angle, H:

$$\cos \mathrm{H} = \frac{\sin \mathrm{h} \ \pm (\sin \delta \ \times \sin \varphi)}{\cos \delta \times \cos \varphi} \tag{3}$$

where h is the altitude, δ is declination and φ is latitude. Hence

$$\cos \mathrm{H} = \frac{\sin 49°10' - \ [\sin(15°58') \ \times \sin(41°)]}{\cos 15°\ 58' \times \cos 41°} = \frac{0{,}7566 - (0{,}2750 \ \times 0{,}6561)}{0{,}9614 \ \times 0{,}7547}$$

$$\cos \mathrm{H} = \frac{0{,}7566 - 0{,}1805}{0{,}7256} = \frac{0{,}5762}{0{,}7256} = 0{,}7940$$

This gives H=37°26' and, dividing this by 15, we get fadl-i dâir to be 2 hours 30 minutes, which is in true solar time. To obtain this result, the following keys of a Privilege calculator are depressed:

CE/C 15.58 °'''→ cos x 41 cos = MS 49.10 °'''→ sin - 15.58 °'''→ sin x 41 sin = ÷ MR = arc cos x 4 = 149.7 minutes of time, which is the result read on the screen.

Since the equation of time is +3 minutes on May 4, it is 2:31 in standard time; hence we see that our clock is approximately 7 minutes fast.

In equation (3), the absolute values of the variables were equated with cos H. If the terrestrial site of the city and the celestial position of the Sun are on the same hemisphere, i.e., if the latitude of the city and the declination of the Sun have the same sign, the (-) sign in the numerator of the formula is used when the Sun is above the horizon, i.e., for diurnal computations, whereas the (+) sign is used in nocturnal calculations. If vice versa, the opposite is done. Fadl-i dâir calculated in this way is the interval between the point where the center of the Sun is and the time of midday (nisf-un-nahâr) during the day, or between that point and midnight at night. The same formula may also be used with only the minus sign in the numerator. In that case, all figures will be substituted with their signs and the resultant H will always be reckoned from the meridian (nisf-un-nahâr).

Let us find the fadl-i dâir according to the second form of the formula (3): on the Privilege calculator, depressing the keys CE/C 49.10 sin - 15.58 MS sin x 41 sin = ÷ MR cos ÷ 41 cos = arc cos ÷ 15 = gives 2hr 29 min 44.59 sec, showing fadl-i dâir to be about 2 hours and 30 minutes.

To modify the apparent altitude of the upper limb of the Sun with respect to the mathematical horizon measured by using an astrolabic quadrant, the corresponding atmospheric refraction and the apparent radius of the Sun are subtracted from and the solar parallax is added to this altitude, and thus the true altitude of the center of the Sun with respect to the true horizon is obtained. In the book **Rub'-i-dâ'ira** by Ahmad Ziyâ Beg, it is written that the times of ishrâq and isfirâr are calculated in the same way as that of checking the accuracy of our clock, (explained a few pages earlier).

We shall now find the time for salât al-'iyd, i.e., the time of **ishrâq**, in Istanbul on January 11. This is the time when the following (lower) limb of the Sun is as high as the length of a spear from the line of the apparent horizon, which corresponds to an altitude where its center is 5° above true horizon. The Sun's declination is -21°53', and it is -21°44' the next day. The daily difference of declination is 9'. Because salât al-'iyd is approximately 8 hours later than midnight and the time in Istanbul is two hours ahead of that in London, the difference of declination for 6 hours is 2'. Since the absolute value of declination is on the decrease in this month, the declination at the time of ishrâq is -21°51'. When the following keys are depressed:

ON 5 sin — 21 51 sin x 41 sin = ÷ 21 51 cos ÷ 41 cos = INV cos ÷ 15 = INV

the calculator (CASIO fx-3600P) reads 4:07. The difference between the (thereby calculated) fadl-i dâir and midday [12:00], 7:53, is the time of ishrâq with respect to the centre of the Sun in true time. Since the equation of time is -8 minutes, it is 8:05 in standard time. 10 minutes of precaution is added and 8:15 is written in calendars. If fadl-i dâir is subtracted from the adhânî time of zuhr [7:22], the time of ishrâq is found to be 3:15 in ghurûbî time. With a view to safeguarding the correct time of salât al-'iyd, the times of duhâ have been taken forward by an amount equal to the period of Tamkin, and, for this purpose, the time of ishrâq in adhânî time has been written in calendars without subtracting the Tamkin. **Kadûsî** says at the end: "Two units of tamkin is, in winter subtracted from and, in summer, added to twice the amount of nisf fadla and the angle complementary to the sum is converted to hours and added to 6. The result is the time of sunrise in adhânî time. If two tamkins are added instead of subtracting and subtracted instead of adding and as a precaution a Tamkin is added to the result, the time of **duhâ**, i.e. the time of the prayer of ishrâq is obtained." The treatise by **Kadûsî's** **Irtifâ'-i sems risâlesi**, was written in 1268 A.H.[1851] and reprinted in 1311.

The time of **isfirâr-i shams** on the same day is the time when the preceding [lower] limb of the Sun approaches the line of the apparent horizon as near as the length of a spear, i.e., the time when the center of the Sun is at an altitude of 5° from true horizon; the time it spans has been stretched to the length of 40 minutes for precautionary purposes. Since isfirâr is approximately 16 hours later than midnight, and since the difference between the times of Istanbul and London is 1 hour and 56 minutes, declination at that time is 5' 16.5" less than that at midnight, that is, it is -21°47' 43.5". Depressing the following keys of the programmable CASIO fx-3600P calculator:

P_1 5 RUN 21 47 43.5 RUN 41 RUN

fadl-i dâir is easily found to be 4 hours 7 minutes 20.87 seconds. Since the true time is 00:00 at zuhr, the time of isfirâr in true time is at the same time the fadl-i dâir itself; and it is 4:15 in mean solar time and 4:19 in standard time. From the sum of the time of zuhr in adhânî time and fadl-i dâir, 11 hours 29 minutes, which is the time of isfirâr in ghurûbî time, a Tamkin is subtracted and the remainder, 11:19, is the time of isfirâr in adhânî time. The time of isfirâr-i shams can also be obtained by subtracting an amount of time one unit of Tamkin shorter than the time of ishrâq written in calendars from the sum of the time of sunset and the time of sunrise in terms of adhânî or local or standard time. The difference of time between the times of isfirâr and sunset is equal to that between the times of ishrâq and sunrise; it is 40 minutes, for precautionary reasons.

The following keys are depressed in order to program the CASIO fx - 3600P calculator so as to use it in the calculation defined above: MODE $\boxed{0}$ P_1 ENT sin - ENT Kin 1 sin x ENT Kin 3 sin = ÷ Kout 1 cos ÷ Kout 3 cos = INV cos ÷ 15 = INV °''' MODE $\boxed{\cdot}$

Let us find the times (’asr awwal and thânî) of late afternoon prayer in Istanbul as of February the 1st. The Sun’s declination is -17°15' and the equation of time is -13 min 31 sec: Since Fay-i-zawâl = tan (complement of maximum altitude, which in turn is: φ - δ), first, the altitudes are found utilizing the formulas:

tan Z_1 = tan (Temâm-i irtifâ’i asr-i evvel)=1 + tan(φ- δ_1) and
tan Z_2 = tan (Temâm-i irtifâ’i asr-i sânî) =2 + tan(φ- δ_2)

where φ is latitude, δ_1 and δ_2 are declinations for ’asr awwal and ’asr thânî respectively, Z_1 is the angle complementary to the altitude for ’asr awwal, and Z_2 is the angle complementary to the altitude for ’asr thânî. The series of operations,

CE/C 41 - 17.15 °'''→ +/- = tan + 1 = arc tan MS 90 - MR = →°'''

gives the altitude for ’asr awwal to be 20°55', and the series of operations,

20.55 °'''→ sin - 17.15 °'''→ +/- MS sin x 41 sin = ÷ MR cos ÷ 41 cos = arc cos ÷ 15 = →°'''

gives fadl-i dâir to be 2 hours and 40 minutes on a Privilege calculator. Adding Tamkin of 10 minutes for Istanbul to this result, the time for ’asr awwal comes out to be 2:50 in true solar time, 3:04 in mean solar time, and 3:08 in standard time. Addition of fadl-i dâir to the adhânî time of zuhr (7:03) gives ’asr awwal to be 9:43 in ghurûbî and in adhânî times.

The series of operations,

CE/C 41 - 17.15 °'''→ +/- = tan + 2 = arc tan MS 90 - MR = →°'''

gives the altitude for ’asr thânî to be 15°28', and the operations,

15.28 °'''→ sin - 17.15 °'''→ +/- MS sin x 41 sin = ÷ MR cos ÷ 41 cos = arc cos ÷ 15 = →°'''

gives fadl-i dâir to be 3 hours 21 minutes. The time for ’asr thânî comes out to be 3:31 in true solar time, 15:45 in mean solar time, 15:49 in standard time, and 10:24 in ghurûbî and in adhânî times.

We can find the time of imsâk on August 13 also with the use of the first form of the equation (3): Depressing the keys

CE/C 19 sin + 14.50 °'''→ MS sin x 41 sin = ÷ MR cos ÷ 41 cos = arc cos ÷ 15 = →°''' of the Privilege

gives fadl-i dâir (time of hour angle) to be 3 hours 10 minutes. The time of imsâk for Istanbul in true solar time is obtained to be 3:00 hours in true solar time by subtracting 10 minutes of Tamkin and adding it to midnight.

Since this time of fadl-i dâir calculated for fajr-i sâdiq cannot be subtracted from midnight, [from zero, that is,] it is subtracted from 12 hours and, adding 10 minutes of Tamkin, we obtain the time of ’ishâ thânî for the night prayer to be exactly 9 o’clock in true solar time. Adding the fadl-i dâir to the adhânî time of zuhr corresponding to midnight, [05:07], and subtracting 20 minutes (two Tamkins), we obtain 7:57, which is the adhânî time of imsâk.

Let us defermine the time of ’ishâ’-i-awwal on August 13. On a programmed CASIO fx-3600P, keying,

P_1 17 + +/- RUN 14 °’’’ 50 °’’’ RUN 41 RUN
the fadl-i dâir, FD=H is found to be 08:36 hours. Since true time is 00:00 hours at the time of zawâl, the time of ’ishâ-i-awwal, by adding 10 minutes of Tamkin, is found to be 8:46 pm (or 20:46) in true time, 8:55 pm (or 20:55) in standard time. As the time of zuhr in adhânî time is 5:07, the adhânî time of ’ishâ’-i-awwal is 13:41 hours or 1:43 pm.

Time for late afternoon prayer found, using the equation with the square root, for August 13 can also be calculated using the electronic calculator (light-operated CASIO); depressing the keys:

ON 26 °’’’ 10 °’’’ tan
gives 0.4913 as fay-i-zawâl; depressing the keys,
ON 1.4913 INV tan INV °’’’
gives 56°09' as the angle complementary to the altitude for ’asr awwal, and depressing the keys,
75 °’’’ 10 °’’’ + 49 + 56 °’’’ 9 °’’’ = ÷ 2 = INV °’’’
gives M to be 90°09'30", and depressing the keys,
ON 15 sin x 41 °’’’ 10 °’’’ sin ÷ 75 °’’’ 10 °’’’ sin ÷ 49 sin = √ INV sin x 2 ÷ 15 = INV °’’’
fadl-i-dâir is calculated as 3 hours 51 minutes.
Since the altitude for ’asr-i awwal is 33°51', using a battery operated programmable CASIO fx-3600P calculator, if we depress on the keys
P_1 33 °’’’ 51 °’’’ RUN 14 °’’’ 50 °’’’ RUN 41 RUN
the time of hour angle, H is found to be 3 hours 51 minutes.

THERE ARE THREE TIMES WHEN IT IS MAKRÛH TAHRÎMÎ, THAT IS, HARÂM, TO PERFORM SALÂT. These three times are called **times of Karâhat**. A salât is not sahîh (valid) if it is fard and is started at one of these times. If it is supererogatory, it will be sahîh but makrûh tahrîmî. Supererogatory prayers begun at these times must be stopped and performed later (qadâ). These three times are the period of sunrise, that of sunset, and the period when the Sun is at zawâl, i.e. at midday. In this sense, the period of sunrise begins when the upper limb of the Sun is seen on the horizon and ends when it shines too brightly to be looked at, i.e., at the **time of Duhâ;** at the time of Duhâ the altitude of the Sun’s center from true horizon is 5°; its lower limb is a spear’s length above the üfq-i-mer’î. The time of Duhâ is approximately 40 minutes after sunrise. The period between these times, i.e. between sunrise and Duhâ, is the **time of Karâhat**. It is an act of sunnat to perform two rak’ats of **salât-i-ishrâq**, termed **Kushluk namâzı** (in Turkish) when the time of Duhâ comes. The salât al ’iyd, or namâz of ’iyd, also is performed at this time. The period of sunset begins when, in a dustfree, smogless, clear sky, the places where sunlight is reflected on, or the Sun itself, become yellow enough to be looked at, and ends as it sinks (below the horizon). This time is termed **isfirâr-i-shams**. In calculations, the time of ishrâq has been taken forward by the addition of Tamkin as a precaution, but the time of isfirâr has not been changed. “To perform salât at midday” means that the first or the last rak’a of it is performed at midday. This fact is written in Ibn ’Âbidîn, and in Tahtâwî’s annotation to it, entitled **Marâqil-falâh**.

As is stated above, not the various apparent altitudes relative to the lines of different visible horizons of different heights but the shar’î altitudes relative to the location’s established shar’î horizon should be taken into account in calculations of all prayer times. Accordingly, the time of shar’î zawâl is the period between the two times when the preceding and following limbs of the Sun are at their daily ultimate altitudes from the points on the shar’î horizon where it rises and sets, respectively. It is equal to twice the amount of Tamkin for that city. For example, at the time of true zawâl in Istanbul on May 1, the ghâyat irtifâ’ = maximum altitude of the center of the Sun from the true horizon is

49°+14.92°=63.92°. This is the same altitude from the (two) true horizons, (one in the east, above which it rises, and the other in the west, below which it sets). The interval of fadl-i dâir is H=00:00 for this altitude. True zawâl in true time is always at 12:00 everywhere. However, the time of shar'î zawâl corresponding to its daily ultimate altitude from the shar'î horizon in the eastern side begins one period of Tamkin earlier than 12:00. And the time of shar'î zawâl corresponding to its daily ultimate altitude relative to the shar'î horizon in the western side comes later than the true zawâl by the amount of Tamkin. In other words, the time of shar'î zawâl for Istanbul begins 10 minutes earlier than 12:00 in true time. In standard time, the shar'î zawâl period begins at 11:51 and ends at 12:11 because the Equation of Time is +3 minutes. The **time of zuhr,** as given in calendars, for those who are unable to see the Sun starts at this time. The interval of 20 minutes between the two is the time of zawâl, or **time of kerâhat**, for Istanbul. [See the translation of **Shamâil-i Sherîfa**, by Husamaddîn Efendi.]

Since the true altitude, h, of the Sun is zero at the times of true sunset and sunrise, the Equation 3 a few pages earlier becomes - tan φ x tan δ = cos H. Hence, on May 1, cos H=-0.23, the angle of fadl-i-dâir = 103,4° and H=6:54, and the time of true sunset is at 6:54 in true time, at 6:51 in local mean time, and at 6:55 in standard time; and the time of shar'î sunset is 07:05. The time of sunrise in true time=12:00-H=05:06, which corresponds to 05:03 in mean time. To find the time of shar'î sunrise, the Tamkin at sunrise for Istanbul, i.e. 10 minutes, is subtracted from this. 04:53 is the remainder, which corresponds to 04:57 in standard time. The time of zuhr in adhânî time is 05:06, from which [or from its sum with 12:00] fadl-i dâir is subtracted to yield the time of true sunrise in ghurûbî time, and subtracting twice the Tamkin from this, the time of shar'î sunrise is obtained to be 09:52 in adhânî time. The time of true sunset in ghurûbî time and that of shar'î sunset in adhânî time are 12:00 hours, which is, at the same time, the sum of the time of zawâl in ghurûbî time and the time of fadl-i-dâir, i.e. 05.06+06.54=12 hours.

The velocity of light is 300000 kilometres per second. Since the distance between the Sun and the Earth is approximately 150 million kilometres, it takes 8 minutes 20 seconds for the light of the Sun to reach the Earth. Sunrise can be observed only that length of time later than it actually takes place. There are two kinds of solar positions whereby time is reckoned: The first one, **riyâdî** time, begins when the center of the Sun reaches the time of zawâl or the true time of setting. The second one, the **mer'î** time, begins when the Sun can be observed to reach one of these two temporal positions. The mer'î time begins eight minutes and twenty seconds after the riyâdî time. When 8 minutes and 20 seconds is added to the riyâdî time of a certain (daily prayer termed) namâz, which is found by calculation, its mer'î time will be found. When 8 minutes and 20 seconds is subtracted from this, the mer'î time read on timepieces will be found. The times of sunrise, as well as times of all daily prayers, and also the indications of time read as 12 on timepieces, represent the mer'î time. In other words, they correspond to the apparent celestial positions of the Sun. As is seen, the times indicated on timepieces represent also the riyâdî times determined by calculation.

The only prayer that a Muslim is allowed to perform during the period of sunset is the day's late afternoon ('asr) prayer, (which they have somehow failed to perform till then). According to Imâm Abû Yûsuf, it is not makrûh only on Friday to perform a supererogatory prayer when the Sun is at culmination; yet this report is a weak one, (i.e. it falls into the category of reports termed qawl da'îf). At any of these three times, (, i.e. the period of sunrise, that of sunset, and the period when the Sun is at zawâl,) the salât for a janâza[1] that was prepared earlier (than the beginning of the makrûh period) or sajda-i tilâwat or sajda-i sahw are not permissible, either. However, it is permissible to perform the salât of a janâza if the preparation for burial is finished within (one of) those (makrûh) times.

There are two periods of time during which only supererogatory salât is makrûh to perform. From dawn till sunrise in the morning no supererogatory other than the sunna of morning prayer should be performed. After performing the late afternoon prayer, it is makrûh to perform any supererogatory prayer within the period between that time and evening prayer. It is makrûh to begin performing the supererogatory, that is, the sunna, when the imâm mounts the minbar on Friday and as the muezzin (or muadhdhin) says the iqâma and while the imâm leads the jamâ'a at any other prayer time; an exception from this is the sunna of morning prayer, and then this must be performed far behind the lines of jamâ'a or behind a pillar. There are some scholars who say that the sunna which has been started before the imâm mounted the minbar must be completed.

If the Sun begins to rise as you are performing morning prayer, the prayer will not be sahîh. If the Sun sets as you are performing late afternoon prayer, the prayer will be sahîh. If a Muslim flies towards west by plane after performing evening prayer and if he sees the Sun, (after arriving their destination in the west), he must perform the evening prayer again when the Sun sets (with respect to their new location).

In the Hanafî Madhhab, two separate prayers must be performed in succession, (an application termed jem',) only by hadjis (Muslims on pilgrimage); and they must do so at two places: at the place called 'Arafât and at the Muzdalifa. In the Hanbalî Madhhab, it is permissible to perform two prayers one after the other during long-distance journeys[1], in case of illness, for a woman during lactation and during istihâda, in case of excuses ('udhr) that break the ablution, for those who have great difficulty in performing ablution or tayammum or cannot know prayer times such as blind people and underground workers, and for a person whose life, property, livelihood or chastity is in danger. For those who cannot leave their duties for performing salât, it is not permissible to postpone it till after its prescribed time in the Hanafî Madhhab. Only on such days, it becomes permissible for them to follow the Hanbalî Madhhab and perform early and late afternoon prayers together or evening and night prayers together by taqdîm (performing the later one in the time of the earlier one) or ta'khîr (performing the ealier one in the time of the later one). When making jem', it is necessary to perform the early afternoon prayer before the late afternoon prayer and the evening prayer before the night prayer, to intend for jem' when beginning the earlier prayer, to perform the two prayers one immediately after the other, and to observe the fards and mufsids of ablution, ghusl and salât prescribed in the **Hanbalî Madhhab**. (Please click here for information about jem'.)

Definition and estimation of the angle of inhitât (dip of horizon) D for a high place has already been given earlier in the text. This angle is determined by
cos D = r/(r+Y) = 6367654/(6367654+Y) or

$$\boxed{D \cong 0.03 \times \sqrt{Y}\,\text{degrees},} \quad (1)$$

where **r** is the radius of the Earth, **Y** is the height in meters, **D** is the dip of horizon in angular degrees.

The fadl-i-dair (hour angle), H, anywhere, can be computed in degrees and converted into hours and minutes as reckoned from midday (nisf-un-nahâr), using a scientific calculator. The operations on a solar Privilege calculator are as follows:

$$\begin{array}{|c|}\hline \text{h sin} - \varphi\ \text{sin} \times \delta\ \text{sin} = \div\ \varphi\ \text{cos} \div\ \delta\ \text{cos} = \\ \text{arc cos} \div 15 = \boxed{\rightarrow\circ\,'''} \\ \hline \end{array} \quad (2)$$

where h, the angular altitude of the Sun, is minus (-) during the night; and φ, the latitude of the location and δ, the Sun's declination, are minus (-) if the location in question is on the southern hemisphere.

The adhânî time of imsâk (in hours)= 12 + Zuhr - H - (1 ÷ 3). The time of 'ishâ' (in hours) = H + Zuhr - 12. Prayer times anywhere can be determined in standard time utilizing the following operations:

$$\boxed{\mathrm{H} + \mathrm{S} - \mathrm{T} = \div 15 + 12 - \mathrm{E} + \mathrm{N} = \mathrm{INV}\ \boxed{\circ\,'\,'\,'}} \quad (3)$$

on a CASIO-fx3600P calculator where
H = hour angle (fadl-ı dâir), in angular degrees,
S = standard meridian, in angular degrees,
T = longitude of the location, in angular degrees,
E = equation of time, hours,
N = Tamkin, hours.

In these operations, the variables are to be substituted in angular degrees for **H**, **S** and **T** and in hours for **E** and **N**. The signs of **H** and **N** are negative in a.m. and positive in p.m. times.

The period of Tamkin should be calculated as explained previously. For any location where the latitude is less than 44° and the height, Y, of the highest place is less than 500 meters, the amount of Tamkin is obtained in hours with the operations,

$$0.03 \times \mathrm{Y} \sqrt{} + 1.05 = \sin \div \varphi \cos \div \delta \cos \times 3.82 = \mathrm{INV}\ \boxed{\circ\,'\,'\,'} \quad (4)$$

On any day, the declination of the Sun and equation of time and, for locations with latitude 41°, nisf fadla, fadl-i-dâir, and prayer times can be determined easily and rapidly by using the astrolabic quadrant **(Rub'-i dâ'ira)**, which needs no calculation, formula or calculator. It is manufactured and distributed along with an instructions manual by Hakîkat Kitabevi in Istanbul. An empty diskette is placed in a computer and prayer times are fed in. The diskette thus programmed can be taken out and stored for years. It is only a matter of seconds to drive it into a computer, feed in the latitudinal and longitudinal degrees of any city, and see a day's or a month's or a year's prayer times on the monitor. Another few seconds' time will suffice to obtain a piece of paper (containing the prayer times) from the computer and fax it to the city in question.

[In the Mâlikî and Shâfi'î Madhhabs, during a long-distance journey and/or in case of illness and/or old age, early and late afternoon prayers, as well as evening and night prayers, may be performed in (a convenience termed) jem', which means to perform each pair in sucession at the time of one or the other making up the pair.]

To Make Jem'

In the Hanbalî Madhhab, it is permissible to make jem' of evening and night prayers, (i.e. to perform one immediately after the other,) at home for reasons such as cold weather, winter, mud, and storm, as well as the excuses stated before in Prayer Times topic, during a journey of 80 kilometres. The sunnats are not performed when making jem'. You make niyyat (intention) when beginning the earlier one of the two salâts. People with duties and jobs inconvenient for them to perform early and late afternoon and evening prayers within their prescribed periods should imitate the Hanbalî Madhhab and make jem' of early and late afternoon prayers and evening and night prayers instead of resigning from office. If they resign from office, they will share the responsibility for the cruelties and irreligious activities likely to be perpetrated by people who will fill the vacancies they have occasioned. In the Hanbalî Madhhab, there are six fards (compulsory acts): for ablution: to wash the face together with inside of the mouth and the nostrils; to make niyyat (intention); to wash the arms; to make masah (rub the wet hands gently) on the entire head, on the ears, and on the piece of skin above them; [masah is not made on hanging parts of long hair. In the Mâlîkî Madhhab, on the other hand, masah is compulsory on the hanging parts as well;] to wash the feet together with the ankle-bones on the sides; tertîb, [i.e. to observe the prescribed order;] muwâlat [quikness]. (If the person imitating the Hanbalî Madhhab is a male Muslim,) his ablution will be broken if he feels lust in case he touches his male organ. When a women touches him, however, his ablution will not be broken even if he feels lust. Anything emitted by the skin will break the ablution if it is in a ablution. Situation in which a person has an 'udhr are the same as those in the Hanbalî Madhhab, (which are explained in the last six paragraphs of the third chapter.) In ghusl, (which is explained in the fourth chapter,) it is fard to wash inside the mouth and the nostrils and the hair, and for men to wash their plaited hair, (if they have plaited hair). It is sunnat (if ghusl is made for purification from janâbat), and fard (if it is made for purification from the state of menstruation), for women to undo their plaited hair. It is fard to sit as long as a (duration of time that would enable a person to say a certain prayer termed) tashahhud (during the sitting posture in namâz) and to make the salâm by turning the head to both sides (at the end of namâz). (These are the principles that people who imitate the Hanbalî Madhhab have to learn and observe.)

Times of Karâhat

There are three periods of time during which it is makrûh tahrîmî, i.e. harâm (forbidden), to perform a namâz. If the namâz you start to perform within one of these three periods is (an obligatory prayer termed) fard, it will not be sahîh (valid). If it is (a supererogatory one termed) nâfila, you will have committed an act of (harâm termed) makrûh tahrîmî, although the namâz you perform will be sahîh. Such supererogatory prayers of namâz should be discontinued, and reperformed at some other time. The first of these three periods of time begins as the Sun rises in the morning, and continues for forty (40) minutes. The end of this period is termed the **time of dhuhâ** or the **time of ishrâq**. The second period (or time) of karâhat is when the Sun is at culmination, (or zawâl).

And, forty (40) minutes prior to sunset begins the third period of karâhat. Sunrise is the duration of time that begins with the time of tulû', i.e. the time when the upper limb of the Sun emerges on the (visible horizon termed) ufq-i-mer'î, and continues until it ascends to a height at which it is too bright to look at (with the naked eye), i.e. until the time of dhuhâ, which is at the same time the end of the **time of karâhat**. When we say that the Sun is at culmination (in the Islamic sense) we mean that it is within the celestial circle that circumscribes the region termed the shar'î (Islamic) zawâl. In other words, it is the period of time between the time a period of Tamkin prior to true culmination and the time another periof of Tamkin after it. This period of time begins, say, in Istanbul, twenty (20) minutes before the early afternoon prayer. By 'sunset' we mean the time that starts when the Sun begins turning pale enough to be looked at and continues until it sets. The length of this time varies between thirty-seven minutes and forty minutes at locations on latitude 41 degrees North, such as Istanbul. It averages out at forty minutes. The beginning of this time is called **isfirâr-i-shams** or time of karâhat. Only the day's late afternoon prayer (and only its fard part) can be performed as the Sun sets. And then it is makrûh tahrîmî to delay the late afternoon prayer until the time of isfirâr. According to Imâm Abû Yûsuf, only on Friday, it is not makrûh tahrîmî to perform a nâfila namâz when the Sun is directly overhead. However, this qawl (narration conveyed on the authority of the great disciple of Imâm a'zam Abû Hanîfa) is (among those narrations termed) da'îf. Other impermissible acts of worship within this period are performing the namâz of janâza for a dead Muslim if the burial preparations were made beforehand, and to perform prostrations called sajda-i-tilâwat and sajda-i-sahw. If the funeral preparations are made within this period, then it is sahîh to perform the namâz of janâza within this period.

There are two periods of time wherein only nâfila prayers of namâz are makrûh to perform. In the morning, no supererogatory namâz, with the exception of the sunnat of (the day's) morning prayer, are performed between the break of dawn and sunrise. Once the day's late afternoon prayer has been performed. it is makrûh tahrîmî to perform a nâfila namâz before evening prayer. After the imâm has mounted the minbar and the muazzin has started saying the iqâmat on Friday, and as the imâm conducts the fard namâz in jamâ'at at other times, it is makrûh to start performing a nâfila namâz, e.g. the time's sunnat. The only sunnat namâz that is not makrûh to start performing in such cases, is the sunnat of morning prayer; and then this prayer should be performed at some distance from the line of worshippers, or behind one of the pillars in the mosque. As it was stated (by some authorized scholars), a sunnat namâz that you started performing before the imâm mounted the minbar should be (continued and) completed.

If the Sun rises as you are performing a morning prayer, the prayer will not be sahîh (valid). If the Sun sets as you are performing an evening prayer, the prayer will be sahîh. If, after performing an evening prayer, you fly west by plane and see the Sun, you will have to reperform the evening prayer after sunset. If the same event takes place (as you are fasting in Ramadân and) and you have broken your fast, you will have to make qadâ by reperforming your fast after the 'Iyd.

TABLE EQUATION OF TIME and DECLINATION OF THE SUN (1986 *)

00:00 in Universal Time (UT, GMT)

DATE		E min.sec.	δ ° '
Jan.	0	–02 48	–23 07
	1	03 16	23 03
	2	03 44	22 58
	3	04 12	22 52
	4	04 40	22 47
	5	–05 07	–22 40
	6	05 34	22 33
	7	06 01	22 26
	8	06 27	22 19
	9	06 52	22 11
	10	–07 17	–22 02
	11	07 41	21 53
	12	08 05	21 44
	13	08 28	21 34
	14	08 51	21 24
	15	–09 13	–21 13
	16	09 34	21 02
	17	09 55	20 51
	18	10 15	20 39
	19	10 34	20 27
	20	–10 52	–20 14
	21	11 10	20 01
	22	11 26	19 48
	23	11 42	19 34
	24	11 58	19 20
	25	–12 12	–19 05
	26	12 26	18 51
	27	12 39	18 35
	28	12 51	18 20
	29	13 02	18 04
	30	–13 13	–17 48
	31	13 22	17 32
Feb.	1	13 31	17 15
	2	13 39	16 58
	3	13 46	16 40
	4	13 53	–16 23
	5	13 59	16 05
	6	14 04	15 46
	7	14 08	15 28
	8	14 11	15 09
	9	–14 13	–14 50
	10	14 15	14 31
	11	14 16	14 11
	12	14 16	13 52
	13	14 16	13 32
	14	14 14	–13 12
	15	14 12	–12 51

DATE		E min.sec.	δ ° '
Feb.	15	–14 12	–12 51
	16	14 09	12 31
	17	14 06	12 10
	18	14 01	11 49
	19	13 56	11 28
	20	–13 51	–11 06
	21	13 44	10 45
	22	13 37	10 23
	23	13 29	10 01
	24	13 21	09 39
	25	–13 12	–09 17
	26	13 02	08 55
	27	12 52	08 32
	28	12 42	08 10
Mar.	1	12 31	07 47
	2	–12 19	–07 24
	3	12 07	07 01
	4	11 54	06 38
	5	11 41	06 15
	6	11 28	05 52
	7	–11 14	–05 29
	8	–10 59	05 05
	9	10 45	04 42
	10	10 30	04 18
	11	10 14	03 55
	12	–09 59	–03 31
	13	09 43	03 08
	14	09 26	02 44
	15	09 10	02 20
	16	08 53	01 57
	17	–08 36	–01 33
	18	08 19	01 09
	19	08 01	00 46
	20	07 44	–00 22
	21	07 26	+00 02
	22	–07 08	+00 26
	23	06 50	00 49
	24	06 32	01 13
	25	06 13	01 37
	26	05 55	02 00
	27	–05 37	+02 24
	28	05 19	02 47
	29	05 00	03 11
	30	04 42	03 34
	31	04 24	03 57
Apr.	1	–04 16	+04 20
	2	–03 48	+04 44

DATE		E min.sec.	δ ° '
Apr.	1	–04 06	+04 20
	2	03 48	04 44
	3	03 30	05 07
	4	03 13	05 30
	5	02 55	05 53
	6	–02 38	+06 15
	7	02 21	06 38
	8	02 04	07 01
	9	01 47	07 23
	10	01 31	07 45
	11	–01 15	+08 08
	12	00 59	08 30
	13	00 44	08 52
	14	00 28	09 13
	15	–00 13	09 35
	16	+00 01	+09 56
	17	00 15	10 18
	18	00 29	10 39
	19	00 43	11 00
	20	00 56	11 21
	21	+01 09	+11 41
	22	01 21	12 01
	23	01 33	12 22
	24	01 44	12 42
	25	01 55	13 01
	26	+02 06	+13 21
	27	02 16	13 40
	28	02 25	13 59
	29	02 34	14 18
	30	02 43	14 37
May	1	+02 51	+14 55
	2	02 58	15 13
	3	03 05	15 31
	4	03 11	15 49
	5	03 17	16 06
	6	+03 22	+16 24
	7	03 26	16 40
	8	03 30	16 57
	9	03 34	17 13
	10	03 36	17 29
	11	+03 39	+17 45
	12	03 40	18 00
	13	03 41	18 15
	14	03 42	18 30
	15	03 42	18 45
	16	+03 41	+18 59
	17	+03 40	+19 13

DATE		E min.sec.	δ ° '
May	17	+03 40	+19 13
	18	03 38	19 26
	19	03 36	19 40
	20	03 33	19 52
	21	03 30	20 05
	22	+03 26	+20 17
	23	03 22	20 29
	24	03 17	20 40
	25	03 12	20 51
	26	03 06	21 02
	27	+03 00	+21 13
	28	02 53	21 23
	29	02 46	21 32
	30	02 38	21 42
	31	02 30	21 51
June	1	+02 21	+21 59
	2	02 12	22 07
	3	02 02	22 15
	4	01 52	22 22
	5	01 42	22 29
	6	+01 31	+22 36
	7	01 20	22 42
	8	01 09	22 48
	9	00 58	22 53
	10	00 46	22 58
	11	+00 34	+23 02
	12	00 22	23 07
	13	+00 09	23 11
	14	-00 03	23 14
	15	00 16	23 17
	16	–00 29	+23 20
	17	00 42	23 22
	18	00 54	23 24
	19	01 07	23 25
	20	01 20	23 26
	21	–01 33	+23 26
	22	01 46	23 27
	23	01 59	23 26
	24	02 12	23 25
	25	02 25	23 24
	26	–02 38	+23 23
	27	02 50	23 21
	28	03 03	23 18
	29	03 15	23 16
	30	03 27	23 12
July	1	–03 39	+23 09
	2	–03 50	+23 05

(Continued)

Note: These values are for solar years 1986+4N (n=0,1,2,3,...). For 1987+4N, values corresponding to 6 hours earlier; for 1988+4N, values corresponding to 12 hours earlier (prior to March) and to 12 hours later (from March on); for 1989+4N, values corresponding to 6 hours later are used. For example, for 0 Jan. 1989 (31 Dec. 1988) the declination is determined as follows;

Declination (δ) = -23º 07' - [-23º 07' - (-23º 03')] x 6 / 24 = -23º 06'. Ibrâhîm Fezârî Baghdâdî was the earliest Muslim to devise Rub'-i dâ'ira, namely usturlâb and use it to measure the Sun's altitude. Among the very valuable books that he wrote are **Zeyj-i-Fezârî**, **'Amel-i-bi-l-usturlâb** and **Kitâb-ul-mikyâs-uz-zawâl**. He passed away in 188 [A.D. 803]. Two other extremely valuable books are **Kitâb-ul-usturlâb**, by Usbu' Ghirnâtî (of Granada), who passed away in 426 (hijrî), and **Ridâyat-ul-mubtadî** by Alî bin Ahmad Baghdâdî (of Baghdâd) who passed away in 801 [A.D. 1398] in Egypt.

DATE	E min.sec.	δ ° '	DATE	E min.sec.	δ ° '	DATE	E min.sec.	δ ° '	DATE	E min.sec.	δ ° '
July 1	–03 39	+23 09	16	–04 24	+13 54	Oct. 1	+10 06	–02 59	Nov. 16	+15 21	–18 36
2	03 50	23 05	17	04 12	13 35	2	10 25	03 22	17	15 10	18 51
3	04 02	23 00	18	03 59	13 16	3	10 44	03 46	18	14 58	19 06
4	04 13	22 55	19	03 46	12 57	4	11 03	04 09	19	14 46	19 20
5	04 24	22 50	20	03 32	12 37	5	11 21	04 32	20	14 32	19 34
6	04 34	+22 45	21	–03 17	+12 17	6	+11 39	–04 55	21	+14 18	–19 48
7	04 45	22 39	22	03 03	11 57	7	11 57	05 18	22	14 03	20 01
8	04 54	22 32	23	02 47	11 37	8	12 14	05 41	23	13 48	20 14
9	05 04	22 25	24	02 32	11 17	9	12 31	06 04	24	13 31	20 27
10	05 13	22 18	25	02 16	10 56	10	12 47	06 27	25	13 14	20 39
11	–05 21	+22 11	26	–01 59	+10 36	11	+13 03	–06 50	26	+12 55	–20 51
12	05 29	22 03	27	01 42	10 15	12	13 19	07 12	27	12 37	21 02
13	05 37	21 54	28	01 25	09 54	13	13 34	07 35	28	12 17	21 13
14	05 44	21 46	29	01 07	09 33	14	13 48	07 57	29	11 57	21 23
15	05 51	21 37	30	00 49	09 11	15	14 02	08 20	30	11 35	21 34
16	–05 57	+21 27	Sept. 31	–00 31	+08 50	16	+14 16	–08 42	Dec. 1	+11 14	–21 43
17	06 03	21 17	1	–00 13	08 28	17	14 29	09 04	2	10 51	21 53
18	06 08	21 07	2	+00 06	08 06	18	14 41	09 26	3	10 28	22 02
19	06 12	20 57	3	00 25	07 45	19	14 53	09 48	4	10 04	22 10
20	06 16	20 46	4	00 45	07 23	20	15 04	10 09	5	09 40	22 18
21	–06 20	+20 34	5	+01 05	+07 00	21	+15 15	–10 31	6	+09 15	–22 26
22	06 23	20 23	6	01 24	06 38	22	15 24	10 52	7	08 50	22 33
23	06 25	20 11	7	01 45	06 16	23	15 33	11 13	8	08 24	22 40
24	06 27	19 59	8	02 05	05 53	24	15 42	11 34	9	07 58	22 46
25	06 28	19 46	9	02 26	05 31	25	15 50	11 55	10	07 31	22 52
26	–06 28	+19 33	10	+02 46	+05 08	26	+15 57	–12 16	11	+07 04	–22 57
27	06 28	19 20	11	03 07	04 45	27	16 03	12 36	12	06 36	23 02
28	06 28	19 06	12	03 28	04 23	28	16 08	12 57	13	06 09	23 07
29	06 26	18 53	13	03 49	04 00	29	16 13	13 17	14	05 40	23 11
30	06 25	18 38	14	04 11	03 37	30	16 17	13 37	15	05 12	23 15
31	–06 22	+18 24	15	+04 32	+03 14	31	+16 20	–13 56	16	+04 43	–23 18
Aug. 1	06 19	18 09	16	04 53	02 51	Nov. 1	16 23	14 16	17	04 14	23 20
2	06 16	17 54	17	05 15	02 27	2	16 24	14 35	18	03 45	23 22
3	06 12	17 39	18	05 36	02 04	3	16 25	14 54	19	03 15	23 24
4	06 07	17 23	19	05 58	01 41	4	16 25	15 13	20	02 46	23 25
5	–06 02	+17 07	20	+06 19	+01 18	5	+16 24	–15 31	21	+02 16	–23 26
6	+05 56	16 51	21	06 41	00 54	6	16 22	15 50	22	01 46	23 27
7	05 49	16 34	22	07 02	00 31	7	16 20	16 08	23	01 16	23 26
8	05 42	16 17	23	07 23	+00 08	8	16 17	16 25	24	00 47	23 26
9	05 34	16 00	24	07 44	–00 16	9	16 13	16 43	25	+00 17	23 25
10	–05 26	+15 43	25	+08 05	–00 39	10	+16 08	–17 00	26	–00 13	–23 23
11	05 17	15 25	26	08 26	01 02	11	16 02	17 17	27	00 43	23 21
12	05 08	15 08	27	08 46	01 26	12	15 55	17 33	28	01 12	23 19
13	04 58	14 50	28	09 07	01 49	13	15 48	17 50	29	01 42	23 16
14	04 47	14 31	29	09 27	02 12	14	15 40	18 06	30	02 11	23 12
15	–04 36	+14 13	30	+09 47	–02 36	15	+15 30	–18 21	31	–02 40	–23 08
16	–04 24	+13 54	Oct. 1	+10 06	–02 59	16	+15 21	–18 36	32	–03 09	–23 04

Time of zawâl (as UT = Greenwich time) = 12 h (- if Eastern / + if Western) meridian time

Equivalent – Equation of time

E = (true time) - (mean time).

E: equation of time, δ: declination of the Sun, min: minutes, sec: seconds.

The above values are determined when it was 00:00 in London i.e. at 24:00 (the previous midnight). They are used after correction in direct proportion to a given longtitude. For example, the time t in standart time is calculated from, declination (δ), $\delta = \delta_1 + (\delta_2 - \delta1) \times (t - S/15) / 24$ where δ_1 and δ_2 are the values on that day and on the following, respectively; S is the degree of the meridian determining standart time; all used with their algebraic signs.

Sun's Altitudes at Time of Late Afternoon Prayer for Any Latitude

Ghâyat Irtifa'	Fay-i-zawâl	Ghâyat Irtifa'	Fay-i-zawâl	Ghâyat Irtifa'	Fay-i-zawâl	Ghâyat Irtifa'	Fay-i-zawâl	Ghâyat Irtifa'	Fay-i-zawâl
0 15	229.182	10 30	5.395	25 30	2.097	40 30	1.171	61	0.554
0 30	114.589	11 00	5.145	26 00	2.050	41 00	1.150	62	0.532
0 45	76.390	11 30	4.915	26 30	2.006	41 30	1.130	63	0.510
1 00	57.290	12 00	4.705	27 00	1.963	42 00	1.111	64	0.488
1 15	45.829	12 30	4.511	27 30	1.921	42 30	1.091	65	0.466
1 30	38.188	13 00	4.331	28 00	1.881	43 00	1.072	66	0.445
1 45	32.730	13 30	4.165	28 30	1.842	43 30	1.054	67	0.424
2 00	28.636	14 00	4.011	29 00	1.804	44 00	1.036	68	0.404
2 15	25.452	14 30	3.867	29 30	1.767	44 30	1.018	69	0.384
2 30	22.904	15 00	3.732	30 00	1.732	45 00	1.000	70	0.364
2 45	20.819	15 30	3.606	30 30	1.698	45 30	0.983	71	0.344
3 00	19.081	16 00	3.487	31 00	1.664	46 00	0.966	72	0.325
3 15	17.611	16 30	3.376	31 30	1.632	46 30	0.949	73	0.306
3 30	16.350	17 00	3.271	32 00	1.600	47 00	0.933	74	0.287
3 45	15.257	17 30	3.172	32 30	1.570	47 30	0.916	75	0.268
4 00	14.301	18 00	3.078	33 00	1.540	48 00	0.900	76	0.249
4 15	13.457	18 30	2.989	33 30	1.511	48 30	0.885	77	0.230
4 30	12.706	19 00	2.904	34 00	1.483	49 00	0.869	78	0.213
4 45	12.035	19 30	2.824	34 30	1.455	49 30	0.854	79	0.194
5 00	11.430	20 00	2.747	35 00	1.428	50 00	0.839	80	0.179
5 30	10.385	20 30	2.675	35 30	1.402	51 00	0.830	81	0.158
6 00	9.514	21 00	2.605	36 00	1.376	52 00	0.781	82	0.141
6 30	8.777	21 30	2.539	36 30	1.351	53 00	0.754	83	0.123
7 00	8.144	22 00	2.475	37 00	1.327	54 00	0.727	84	0.105
7 30	7.596	22 30	2.414	37 30	1.303	55 00	0.700	85	0.087
8 00	7.115	23 00	2.356	38 00	1.280	56 00	0.675	86	0.070
8 30	6.691	23 30	2.300	38 30	1.257	57 00	0.649	87	0.052
9 00	6.394	24 00	2.246	39 00	1.235	58 00	0.625	88	0.035
9 30	5.976	24 30	2.194	39 30	1.213	59 00	0.601	89	0.017
10 00	5.671	25 00	2.145	40 00	1.192	60 00	0.577	90	0.000

For instance, the Sun's declination on February 2 is -16º 48′ in Istanbul; hence, ghâyat irtifa' (point of solar culmination, the Sun's maximum altitude) is -16º 48′ + 49º = 32º 12′; fay-i-zawâl (the shortest shadow) of a one-metre-long perpendicular rod is 1.58m.; and the length of its late-afternoon shadow is 2.58m.; and the Sun's late-afternoon altitude is 21º 20′. The fadl-i-dâir (temporal value of the arc of complement of the Sun's true altitude) is 2 hours and 41 minutes, which will be found by using a calculator. Thereby the time of late afternon will be found to be 9:42 hours, adhâni, and 3:09 hours, in standard time, since the equation of time is -13 minutes 39 seconds; (Please click here to see Table Equation of Time and Declination of The Sun) A method to be used in the absence of the chart above is to get a privileg calculator, touch the buttons for the computation: 90 - 32.12  = tan + 1 = arc tan MS 90 - MR =  , and find the Sun's altitude at the time of 'asr-i awwal (the earlier time of late afternoon) to be 21º 08′. There is yet another method: The Rub′-i-dâira (quadrant). Its khayt, (thread that represents the daily rotation,) is brought over the number representing the ghâyat irtifâ'; the number on the arc of zill-i-mebsût and crossed by the khayt shows the length of the shortest shadow termed fay-i-zawâl.

Table of Tamkin Periods

The following table contains values of Tamkin calculated for latitudes zero through sixty degrees (inclusive) on a five-hundred-metre scale graduated into multiples of twenty-five.

The uppermost orange-coloured horizontal line of values on the table represents elevations from zero to five hundred metres graduated from left to right, and the first vertical line of orange-coloured figures arranged so as to increase on a downward direction indicates latitudes from zero to sixty degrees. Figures whereon the two lines of values intersect are the values of Tamkin in minutes and seconds. For instance, period of Tamkin for an elevation of 250 metres on latitude 2° is 6 minutes and 25 seconds, as is indicated in orange colour on the following table.

TABLE OF TAMKINS

LATITUDE	E L E V A T I O N (METRES)																				
	0 m	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.
0°	3.49	4.38	4.58	5.16	5.27	5.38	5.49	5.58	6.08	6.17	6.25	6.31	6.40	6.47	6.54	7.01	7.08	7.14	7.20	7.26	7.32
1°	3.49	4.38	4.58	5.16	5.27	5.38	5.49	5.58	6.08	6.17	6.25	6.32	6.40	6.47	6.54	7.01	7.08	7.14	7.20	7.26	7.32
2°	3.49	4.38	4.58	5.16	5.27	5.38	5.50	5.58	6.08	6.17	6.25	6.33	6.40	6.47	6.54	7.01	7.08	7.14	7.20	7.26	7.32
3°	3.49	4.38	4.58	5.16	5.27	5.39	5.50	5.59	6.09	6.17	6.25	6.33	6.41	6.48	6.55	7.02	7.09	7.15	7.21	7.27	7.33
4°	3.50	4.39	4.59	5.17	5.28	5.39	5.51	6.00	6.09	6.17	6.25	6.33	6.41	6.48	6.55	7.02	7.09	7.15	7.21	7.28	7.34
5°	3.50	4.39	4.59	5.17	5.28	5.40	5.51	6.01	6.10	6.18	6.26	6.34	6.42	6.49	6.56	7.03	7.10	7.16	7.22	7.28	7.34
6°	3.51	4.39	5.00	5.18	5.29	5.40	5.52	6.01	6.10	6.18	6.26	6.34	6.42	6.49	6.56	7.04	7.11	7.17	7.23	7.29	7.35
7°	3.51	4.40	5.00	5.19	5.29	5.41	5.52	6.01	6.11	6.19	6.27	6.34	6.42	6.49	6.57	7.04	7.12	7.18	7.24	7.30	7.36
8°	3.52	4.40	5.01	5.20	5.30	5.41	5.53	6.02	6.12	6.20	6.28	6.36	6.44	6.51	6.58	7.05	7.13	7.19	7.25	7.31	7.38
9°	3.53	4.41	5.02	5.21	5.30	5.42	5.54	6.03	6.13	6.22	6.30	6.38	6.46	6.53	7.00	7.07	7.14	7.20	7.26	7.32	7.39
10°	3.54	4.42	5.03	5.22	5.32	5.43	5.55	6.04	6.14	6.22	6.31	6.39	6.48	6.55	7.02	7.09	7.15	7.21	7.27	7.34	7.40
11°	3.55	4.43	5.04	5.23	5.34	5.45	5.56	6.06	6.16	6.24	6.32	6.40	6.49	6.56	7.03	7.10	7.17	7.23	7.29	7.36	7.42
12°	3.55	4.45	5.06	5.24	5.35	5.46	5.58	6.08	6.17	6.26	6.35	6.41	6.51	6.58	7.05	7.12	7.19	7.25	7.32	7.38	7.44
13°	3.56	4.46	5.07	5.25	5.36	5.48	6.00	6.10	6.19	6.28	6.37	6.43	6.53	7.00	7.07	7.14	7.21	7.27	7.34	7.40	7.46
14°	3.57	4.47	5.08	5.27	5.38	5.51	6.01	6.12	6.21	6.30	6.39	6.45	6.55	7.02	7.09	7.16	7.23	7.30	7.35	7.42	7.48
15°	3.58	4.49	5.10	5.29	5.40	5.53	6.03	6.14	6.23	6.32	6.41	6.47	6.57	7.05	7.13	7.19	7.25	7.32	7.38	7.44	7.51
16°	4.00	4.50	5.12	5.31	5.43	5.55	6.05	6.16	6.26	6.35	6.44	6.49	7.00	7.07	7.14	7.22	7.28	7.35	7.41	7.47	7.54
17°	4.01	4.52	5.14	5.33	5.45	5.58	6.08	6.18	6.28	6.37	6.46	6.54	7.02	7.09	7.17	7.24	7.31	7.38	7.44	7.50	7.57
18°	4.02	4.54	5.16	5.36	5.47	6.00	6.11	6.21	6.31	6.40	6.49	6.57	7.05	7.12	7.20	7.27	7.34	7.41	7.47	7.54	8.00
19°	4.03	4.56	5.18	5.38	5.50	6.03	6.13	6.24	6.34	6.43	6.52	7.00	7.07	7.15	7.23	7.30	7.38	7.44	7.50	7.57	8.04
20°	4.05	4.58	5.21	5.40	5.52	6.05	6.16	6.26	6.36	6.45	6.54	7.03	7.10	7.18	7.26	7.33	7.42	7.47	7.54	8.00	8.07
21°	4.06	5.01	5.23	5.43	5.55	6.07	6.19	6.29	6.39	6.48	6.57	7.06	7.14	7.22	7.30	7.37	7.45	7.51	7.58	8.04	8.11
22°	4.08	5.02	5.26	5.46	5.58	6.11	6.22	6.32	6.42	6.52	7.01	7.10	7.18	7.26	7.34	7.41	7.49	7.56	8.03	8.09	8.16
23°	4.10	5.06	5.28	5.49	6.02	6.14	6.25	6.36	6.46	6.56	7.05	7.14	7.22	7.30	7.38	7.45	7.55	8.00	8.06	8.13	8.20
24°	4.12	5.08	5.31	5.52	6.05	6.17	6.29	6.40	6.50	7.00	7.09	7.18	7.26	7.34	7.42	7.49	7.57	8.04	8.11	8.18	8.25
25°	4.14	5.11	5.35	5.55	6.08	6.20	6.32	6.43	6.54	7.05	7.15	7.21	7.30	7.38	7.46	7.54	8.01	8.09	8.15	8.22	8.30

LATITUDE																					
26°	4.17	5.15	5.38	5.59	6.12	6.24	6.36	6.47	6.58	7.08	7.17	7.26	7.34	7.43	7.51	7.59	8.07	8.13	8.20	8.28	8.35
27°	4.20	5.19	5.42	6.03	6.15	6.27	6.40	6.52	7.03	7.13	7.22	7.32	7.40	7.49	7.57	8.05	8.12	8.20	8.26	8.34	8.41
28°	4.22	5.22	5.46	6.07	6.19	6.32	6.45	6.56	7.08	7.18	7.28	7.37	7.46	7.55	8.03	8.11	8.18	8.26	8.33	8.40	8.47
29°	4.26	5.27	5.50	6.11	6.23	6.36	6.49	7.01	7.13	7.23	7.33	7.42	7.51	8.00	8.08	8.16	8.24	8.32	8.39	8.46	8.53
30°	4.29	5.31	5.54	6.12	6.27	6.41	6.54	7.06	7.18	7.28	7.38	7.48	7.57	8.05	8.13	8.22	8.30	8.37	8.44	8.52	8.59
31°	4.33	5.34	5.59	6.17	6.32	6.46	6.59	7.12	7.24	7.34	7.44	7.54	8.02	8.11	8.20	8.28	8.36	8.44	8.51	8.58	9.06
32°	4.38	5.37	6.03	6.23	6.38	6.52	7.06	7.18	7.29	7.40	7.50	7.59	8.09	8.17	8.26	8.35	8.43	8.50	8.58	9.05	9.13
33°	4.42	5.41	6.08	6.27	6.44	6.58	7.12	7.24	7.36	7.46	7.57	8.06	8.16	8.25	8.32	8.42	8.51	8.58	9.06	9.13	9.21
34°	4.46	5.47	6.14	6.33	6.50	7.04	7.19	7.31	7.43	7.54	8.05	8.14	8.24	8.33	8.42	8.51	9.00	9.07	9.15	9.22	9.30
35°	4.52	5.54	6.20	6.40	6.57	7.12	7.26	7.38	7.50	8.01	8.12	8.22	8.32	8.42	8.51	9.00	9.08	9.16	9.24	9.32	9.39
36°	4.57	5.59	6.27	6.50	7.04	7.19	7.34	7.47	7.59	8.10	8.21	8.31	8.41	8.52	9.01	9.10	9.18	9.26	9.34	9.42	9.50
37°	5.02	6.06	6.34	6.55	7.12	7.27	7.41	7.54	8.07	8.19	8.30	8.41	8.51	9.01	9.11	9.20	9.29	9.37	9.45	9.53	10.01
38°	5.07	6.16	6.41	7.02	7.20	7.35	7.49	8.02	8.15	8.28	8.41	8.51	9.01	9.11	9.21	9.31	9.39	9.48	9.56	10.04	10.12
39°	5.13	6.20	6.48	7.10	7.28	7.44	7.59	8.13	8.26	8.38	8.49	9.00	9.11	9.21	9.31	9.40	9.49	9.58	10.07	10.15	10.23
40°	5.19	6.26	6.56	7.21	7.38	7.54	8.09	8.23	8.36	8.48	9.00	9.11	9.22	9.32	9.42	9.52	10.01	10.10	10.19	10.27	10.36
41°	5.26	6.33	7.05	7.29	7.47	8.03	8.19	8.33	8.46	8.59	9.11	9.23	9.34	9.45	9.56	10.06	10.16	10.25	10.33	10.41	10.49
42°	5.33	6.42	7.14	7.38	7.56	8.14	8.30	8.45	8.59	9.12	9.24	9.35	9.46	9.57	10.07	10.17	10.27	10.34	10.42	10.50	10.58
43°	5.40	6.52	7.24	7.48	8.08	8.26	8.42	8.56	9.09	9.22	9.35	9.48	10.01	10.13	10.24	10.34	10.44	10.53	11.02	11.10	11.18
44°	5.48	7.03	7.35	8.01	8.20	8.38	8.54	9.09	9.24	9.37	9.50	10.02	10.14	10.25	10.36	10.47	10.58	11.07	11.17	11.27	11.38
45°	5.57	7.13	7.46	8.12	8.33	8.51	9.08	9.24	9.39	9.53	10.06	10.18	10.30	10.41	10.52	11.03	11.14	11.24	11.34	11.44	11.53
46°	6.06	7.26	8.00	8.26	8.47	9.06	9.23	9.40	9.55	10.09	10.22	10.35	10.48	11.00	11.11	11.22	11.33	11.43	11.53	12.03	12.22
47°	6.17	7.38	8.13	8.43	9.01	9.21	9.39	9.55	10.11	10.24	10.38	10.52	11.06	11.18	11.30	11.41	11.53	12.01	12.09	12.17	12.24
48°	6.28	7.52	8.28	8.59	9.19	9.38	9.57	10.14	10.30	10.45	10.59	11.13	11.26	11.39	11.51	12.03	12.15	12.26	12.37	12.48	12.58
49°	6.41	8.04	8.43	9.11	9.35	9.56	10.15	10.33	10.50	11.06	11.22	11.36	11.49	12.01	12.13	12.25	12.36	12.47	12.58	13.09	13.19
50°	6.54	8.19	8.56	9.28	9.54	10.14	10.34	10.54	11.12	11.29	11.44	11.59	12.11	12.25	12.37	12.50	13.02	13.14	13.26	13.37	13.51
51°	7.09	8.40	9.19	9.54	10.16	10.39	11.00	11.18	11.36	11.53	12.09	12.25	12.40	12.54	13.07	13.20	13.32	13.44	13.56	14.08	14.20
52°	7.26	9.02	9.43	10.17	10.44	11.07	11.26	11.46	12.05	12.22	12.39	12.54	13.10	13.25	13.39	13.53	14.06	14.19	14.32	14.44	14.56
53°	7.44	9.26	10.08	10.41	11.07	11.33	11.56	12.16	12.35	12.53	13.10	13.26	13.42	13.57	14.12	14.27	14.42	14.57	15.12	15.26	15.34
54°	8.06	9.54	10.38	11.11	11.39	12.05	12.28	12.51	13.11	13.31	13.49	14.06	14.23	14.38	14.53	15.08	15.23	15.38	15.53	16.08	16.18
55°	8.28	10.22	11.08	11.42	12.12	12.39	13.05	13.27	13.48	14.08	14.27	14.44	15.02	15.20	15.37	15.54	16.10	16.26	16.42	16.58	17.08
56°	8.55	10.52	11.42	12.26	12.52	13.51	13.47	14.11	14.34	14.55	15.15	15.35	15.54	16.12	16.30	16.47	17.03	17.19	17.34	17.49	18.04
57°	9.25	11.20	12.19	13.05	13.39	14.08	14.35	15.00	15.23	15.45	16.06	16.26	16.46	17.05	17.25	17.44	18.03	18.22	18.40	18.58	19.15
58°	10.04	12.08	13.13	13.57	14.34	15.05	15.34	15.59	16.23	16.46	17.08	17.30	17.51	18.11	18.31	18.51	19.11	19.31	19.51	20.11	20.30
59°	10.50	13.06	14.15	15.02	15.41	16.13	16.43	17.11	17.38	18.04	18.28	18.52	19.15	19.38	20.00	20.22	20.44	21.06	21.28	21.49	22.10
60°	11.44	14.20	15.27	16.26	17.06	17.42	18.17	18.49	19.21	19.51	20.20	20.48	21.15	21.41	22.05	22.31	22.55	23.17	23.38	23.59	24.20
	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.
	0 m	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500

E L E V A T I O N (METRES)

Height is the elevation of the highest place of a location above its lowest place. Information about Tamkin is given in the tenth chapter, **Prayer Times**, of Endless Bliss Fourth Fascicle Fourteenth Edition, page number 159. Muhammad bin Mûsâ Baghdâdî and Abû Bakr Muhammad bin 'Umar Munajjim Baghdâdî explained how to determine the time by using the Rub'-i dâira [quadrant] in their books **al-'Amal-u bi-l-usturlâb**. The former passed away in 205, and the latter in 320 [A.D. 932]. Another valuable source is the book **Rubu'i muqantarât** by Abdullah bin Alî Mardînî. He passed away in 779 [A.D. 1377].

Captain Mustafâ Hilmi Efendi, a teacher of fann-i hey'et (astronomy) in the Mekteb-ibahriya-i-shâhâna (Royal Naval Academy), gave perfect calculations of prayer times and of thebeginnings of Arabic months in his book **Hey'et-i felekiyye**, printed in 1306 [A.D. 1888].