

BROCK UNIVERSITY

ASTR 1P01 Introduction to Astronomy I

Phases of the Moon

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The lecture notes present a very nice series of diagrams using which you can determine, for a given phase of the Moon, when the Moon rises and sets, and during which part of the day the Moon is visible. You can also determine what the phase of the Moon is given when it rises or sets relative to the Sun.

In talking to students about this in my office over the past little while, it occurred to me that some students were having difficulties understanding the series of diagrams, and so I wondered whether another method might be helpful. Here's what I came up with.

The key facts that you must remember (or, better, understand) are that the Moon rises at sunset and sets at sunrise when it is full, and that the Moon rises at sunrise and sets at sunset when it is new. Does this make sense? When the Moon is full or new it is aligned with the Earth and Sun, with the Moon between the Sun and Earth when it is new and on the opposite side of the Earth when it is full. Think about this and draw diagrams to make sure you understand it. (You can also refer to the several diagrams in Dr. Mitrović's lecture notes and the textbook.)

Let's record these key facts in a table:

Moon's Phase	Moon Rises	Moon Sets
new	sunrise	sunset
full	sunset	sunrise
new	sunrise	sunset

The next important fact that you should remember (or, better, understand) is that each day the Moon rises and sets about 50 minutes **later** than on the previous day. This fact alone allows us to draw many conclusions based on the table above. For example, when the Moon's phase is a waxing crescent, it rises after sunrise and sets after sunset, because the waxing crescent phase occurs in the days following a new phase and before the first quarter phase.

Some people may prefer to fill in the table a little more, as follows:

Moon's Phase	Moon Rises	Moon Sets
new	sunrise	sunset
Q1	mid-day	middle of night
full	sunset	sunrise
Q3	middle of night	mid-day
new	sunrise	sunset

Other students may prefer to fill in the table completely, as follows:

Moon's Phase	Moon Rises	Moon Sets
new	sunrise	sunset
waxing crescent	between sunrise and mid-day	between sunset and middle of night
Q1	mid-day	middle of night
waxing gibbous	between mid-day and sunset	between middle of night and sunrise
full	sunset	sunrise
waning gibbous	between sunset and middle of night	between sunrise and mid-day
Q3	middle of night	mid-day
waning crescent	between middle of night and sunrise	between mid-day and sunset
new	sunrise	sunset

Can you understand the changes in the Moon's rising times during a cycle of its phases? Run down the second column of the table to see if you understand: When the Moon is new, it rises at sunrise. Each subsequent day of the cycle the Moon rises a little later. By the first quarter, the Moon is rising about half-way between sunrise and sunset, sometime in the middle of the day. The Moon continues to rise later and later each subsequent day, until by the time it is full it rises at sunset. After that, the Moon continues to rise a little later each day, as the table indicates. By the time the Moon is new again, the cycle has completed, and then it repeats.

Now run down the third column of the table to understand the changes in the Moon's setting times during its cycle of phases.

The discussion of the last few paragraphs should allow you to understand how to answer Q39–Q42 on Test 1. For example:

- Q39: Run down the second column of the table until you reach the cell just before sunset; the corresponding phase, which you can see by looking to the left at the cell in the first column, is waxing gibbous.
- Q40: Run down the second column of the table until you reach the cell just before sunrise; the corresponding phase, which you can see by looking to the left at the cell in the first column, is waning crescent.
- Q41: Run down the third column of the table until you reach the cell just before sunset; the corresponding phase, which you can see by looking to the left at the cell in the first column, is waning crescent.

- Q42: Run down the third column of the table until you reach the cell just before sunrise; the corresponding phase, which you can see by looking to the left at the cell in the first column, is waxing gibbous.

Can you visualize the location of the Moon in the sky as it goes through its cycle of phases? Have you been observing the Moon lately? If not, consult diagrams in the lecture notes or textbook, or draw your own diagrams to see if you can understand the following points. When the Moon is new its angular position is the same as the Sun's angular position. When the Moon is full, its angular position is 180° away from the Sun's angular position (they are opposite in the sky). At Q1, the Moon is half-way between new and full, and its angular position is 90° away from the Sun's angular position.

The angular position of the Moon relative to the Sun gradually changes each day, starting at 0° when the Moon is new, gradually increasing as the crescent Moon waxes until the relative angular position between Moon and Sun reaches 90° at Q1. The relative angular position between Moon and Sun continues to increase to 180° when the Moon is full, and then gradually decreases back towards 0° when the Moon passes through the waning gibbous, Q3, and waning crescent phases, until it reaches 0° when the Moon is new again.

The discussion of the last few paragraphs should allow you to understand how to answer Q36 and Q37 on Test 1. In the waxing crescent phase the time between sunrise and the Moon's rise increases every day, so the angle between the Sun and Moon increases each day. In the waning crescent phase, the time between sunrise and the Moon's rise decreases every day, so the angle between the Sun and the Moon decreases each day.

The table can be used to answer all kinds of other questions about lunar phases, such as:

- Is the Moon visible at sunset when it is in a waning gibbous phase? (Answer: No, as you can see from the table, because the Moon rises after sunset and sets before mid-day when in a waning gibbous phase.)
- The Moon is visible from about two hours after sunrise until about two hours after sunset. What is the Moon's phase? (Answer: Waxing crescent, as you can see from the table.)

Play with the table and see if you like using it. Some may like to use it, others may prefer to use the diagrams given in the lecture notes and textbook. Which method you use is not important, as long as it works for you. The key is that you understand what you are doing, and lots of practice, plus visualizing the relative positions of the Moon and Sun will give you a deep understanding of their relative motions as the phase of the Moon changes.

Please feel free to ask questions about anything if you would like to discuss anything with me.