Measuring the distance to the Moon[1]

The ancient Greek astronomer Hipparchus (c. 190–c. 120 BCE) noticed that the Moon shows *parallax*, that is, it appears in a slightly different place in the sky relative to background objects when seen at the same time from different locations on Earth. Knowing the distance between the two locations and having descriptions of the position of the Moon against the Sun during an eclipse (and so, at the same time), he was able to determine the distance to the Moon using trigonometry.

This year, the members of each team are spread out across the globe, which makes for a unique opportunity to perform an analogous experiment and use simultaneous observations from different places on Earth to determine the distance to the Moon in a similar way.

However, the distance of the Moon from the Earth varies over time due to the slight eccentricity of its orbit. The Moon is closest at perigee with a distance of about 360 000 km (called a "supermoon" if the Moon is full) and furthest at apogee, with a distance of about 405 000 km (called a "micromoon"). You are therefore asked to find the distance to the Moon at a specific time.

Your task, as a team, is to plan and carry out a series of observations and calculations to determine the distance of the centre of the Moon from the centre of the Earth at 12:00 UT on 6 October 2020 as well as you can.

1. You may use any observational methods (visual, photographs, video ...), and different members of the team can use different methods, but your final result must be based *only* on observations made by members of the team.
2. You can perform your observations at any time during the Team Competition period (28 September to 12 October) and as many times as you need to. (Note that you do not actually have to observe the Moon exactly at 12:00 UT on 6 October.)
3. If simultaneous observations are impossible you can interpolate the position of the Moon from your own observations, but you must use *only* your own observations with an explanation. Do not use table values or planetarium programs to "guess" the position of the Moon.
4. The more observations you make from different places and the more simultaneous they are, the more accurate your final answer will be.
5. You can look up the diameters of the Earth and Moon (if you need to) and the geographical coordinates (latitude and longitude) of your locations, but any distances (on Earth or to the Moon) must be calculated by you, showing your method.
6. You should prepare a short "paper" which includes at least:
   (a) a brief description of your observations (a short paragraph for each observing "session") including the weather conditions and a discussion of sources of error;
   (b) a table of all of your measurements with estimates of uncertainty;
   (c) discussion of any systematic effects;
   (d) a description of your calculations, including any graphs and diagrams;
   (e) the final result with an uncertainty derived from the measurement errors;
   (f) a short discussion of the result;
   (g) references/bibliography.

[1] In memory of Prof. John H. Seiradakis (1948–2020), team leader from Greece and one of the founders of the IOAA.

7. If planned observations failed for any reason, mention this.
8. Any numerical values taken from external sources (e.g. your location) should be marked and you should provide a reference to the source.
9. You should include an attachment with the raw data (images etc.) or a link to download them (Google, Dropbox etc), so that it is possible to reproduce your work.
10. You should also prepare a short presentation (either as a Powerpoint or PDF of around 10 slides, or as a video no longer than 10 minutes) presenting your team: who you are, where you are from, how the observations were made, and a summary of the results and conclusions. Think of what you would say to present yourselves and your experiment to the other participants at a conference.
    The presentations may be put on the IOAA website, so please do not include detailed personal information (first name/country/nearest large city is enough).

The Academic Committee will be looking for careful and creative planning, observation, calculation and assessment of uncertainties rather than necessarily obtaining a result closest to the "textbook" value or with the smallest uncertainty "on paper". Good scientific methodology counts for more than a lucky result or expensive equipment!