International Astronomy and Astrophysics Competition

Training and Problems

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Problem: 2019-QR-A

Fill in the blank spaces with the correct information:

The earth has a distance of (1) light minutes to our sun. When the moon covers the sun we call this event a (2). There are eight planets in the solar system and (3) is the heaviest of them all. The smallest planet is (4) and it circles the sun in just (5) days. Besides the planets, there are thousands of stars visible in the night sky. The brightest star is called (6) and it is just one of about (7) billion stars in our Milky Way. The (8) galaxy is the closest spiral galaxy to our Mily Way.

Problem: 2020-QR-A

Fill in the blank spaces with the correct information:

The Sun is in the center of Solar System and is composed mainly of the elements (1) and (2). The distance from the Earth to the Sun is also called (3). Many people dream about building a colony on Mars, but the atmosphere is primarily made of (4). We have discovered the (5) between Mars and Jupiter, which contains millions of small objects. Jupiter has a total of (6) moons: The four largest moons are easily visible with a telescope and (7) is the closest and most active one. Uranus and Neptune are the outermost planets and it takes Neptune (8) years to complete one orbit around the Sun.

Problem: 2019-QR-B

The Earth has a radius of $R_E \approx 6371\ km$ and an average density of $\rho_E \approx 5.514\ \frac{g}{cm^3}$. Jupiter is much bigger and heavier with a radius of $R_J \approx 70000\ km$ and an average density of $\rho_J \approx 1326\ \frac{kg}{m^3}$. Use these values to answer following questions:

(a) Approximately how many Earths fit into Jupiter (by volume)?
(b) How many times heavier is Jupiter compared to Earth?

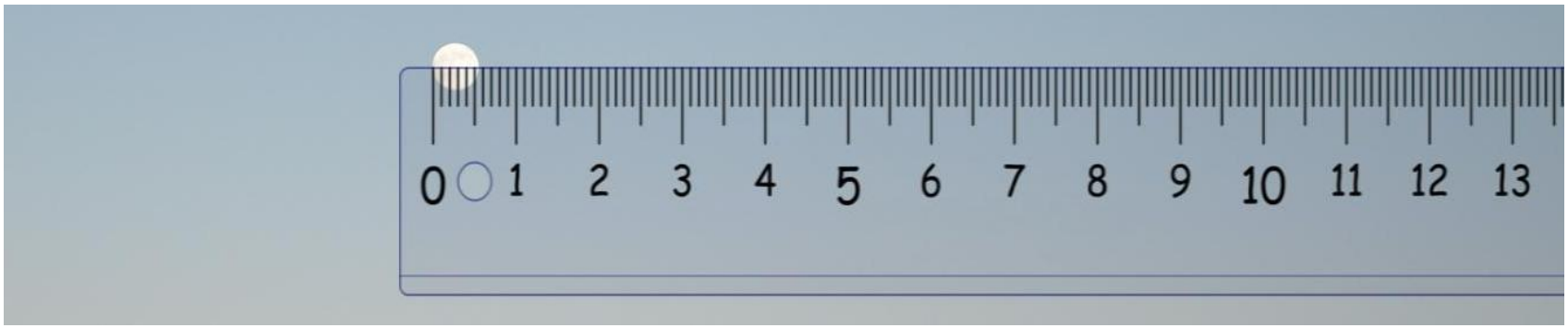
Problem: 2020-QR-B

Assume the diameter of the Earth (12,700 km) is scaled down to 1 cm and answer the following:

(a) How large is the Sun (diameter: 1.4×10^6 km) on this scale?
(b) How far away is the nearest star (4.24 light-years) on this scale?

Problem: 2020-QR-C

During the daylight, you hold a ruler in a distance of 60 cm away from your eyes, and you find the size of the Moon to be 0.55 cm (try it yourself!). At night, you use a telescope to observe rock formations and craters on the Moon to estimate the diameter of the Moon to be about 3500 km.



Find the distance to the Moon by using only the information from this experiment.

Problem: 2019-PF-A

The Milky Way has a diameter of about 150,000 light years. Our solar system is located 27,000 light years from the center of the Milky Way and orbits the center with a speed of 220 km/s.

(a) How long does it take for the solar system to circle the center of the Milky Way?
(b) The earth has formed about 4.5 billion years ago. How often has the earth circled the center?

Problem: 2020-PF-A

The star Sirius has an apparent magnitude of -1.46 and appears 95-times brighter compared to the more distant star Tau Ceti, which has an absolute magnitude of 5.69.

(a) Explain the terms *apparent magnitude*, *absolute magnitude* and *bolometric magnitude*.
(b) Calculate the apparent magnitude of the star Tau Ceti.
(c) Find the distance between the Earth and Tau Ceti.

Problem: 2020-PF-A

Because your spaceship has an engine failure, you crash-land with an emergency capsule at the equator of a nearby planet. The planet is very small and the surface is a desert with some stones and small rocks laying around. You need water to survive. However, water is only available at the poles of the planet. You find the following items in your emergency capsule:

- Stopwatch
- Electronic scale
- 2m yardstick
- 1 Litre oil
- Measuring cup

Describe an experiment to determine your distance to the poles by using the available items.
Hint: *As the planet is very small, you can assume the same density everywhere.*

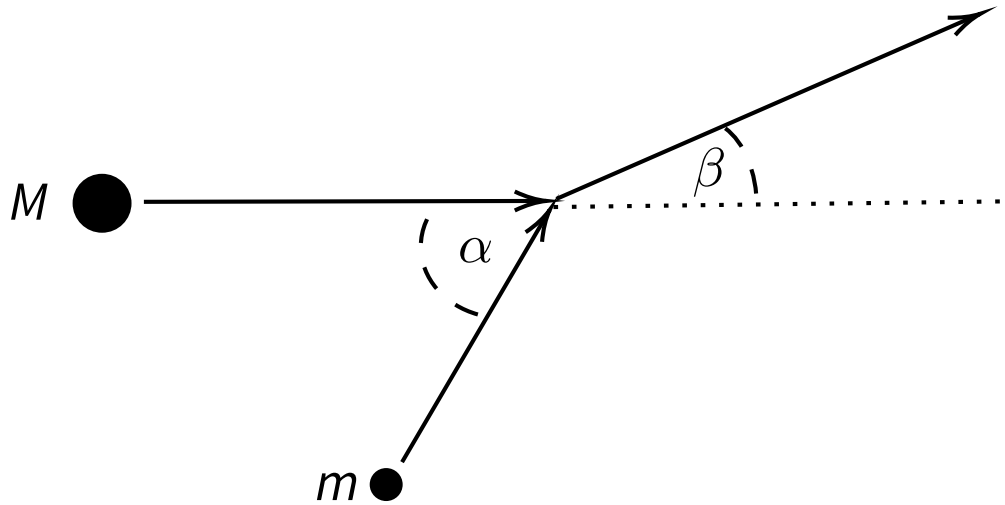
Problem: 2019-PF-B

You have discovered a new star in the Milky Way: Your new star is red and has $3/5$ the temperature of our Sun. The new star emits a total power that is 100,000 times greater than the power emitted by our Sun.

(a) Determine the spectral type (i.e. spectral classification) of the new star.
(b) How many times bigger is the radius of the new star compared to the radius of our Sun?

Problem: 2019-PF-B

A warning system has calculated that two asteroids will collide not far from Earth any time soon. The smaller asteroid has the mass m and moves with the velocity v_m. The bigger asteroid has the mass $M = 3m$ and the velocity of $v_M = \frac{1}{2}v_m$. They collide at an angle of $\alpha = 60°$ and turn into a single heavy asteroid (inelastic collision):



(a) Calculate the velocity of the single object after the collision.
(b) Determine the angle β after the collision.

Problem: 2020-PF-B

Our Sun shines bright with a luminosity of 3.828×10^{26} Watt. Her energy is responsible for many processes and the habitable temperatures on the Earth that make our life possible.

(a) Calculate the amount of energy arriving on the Earth in a single day.
(b) To how many litres of heating oil (energy density: 37.3×10^{6} J/litre) is this equivalent?
(c) The Earth reflects 30% of this energy: Determine the temperature on Earth's surface.
(d) What other factors should be considered to get an even more precise temperature estimate?

Note: The Earth's radius is 6370 km; the Sun's radius is 696×10^{3} km; 1 AU is 1.495×10^{8} km.

Problem: 2020-PF-B

The table below lists the average distance R to the Sun and orbital period T of the first planets:

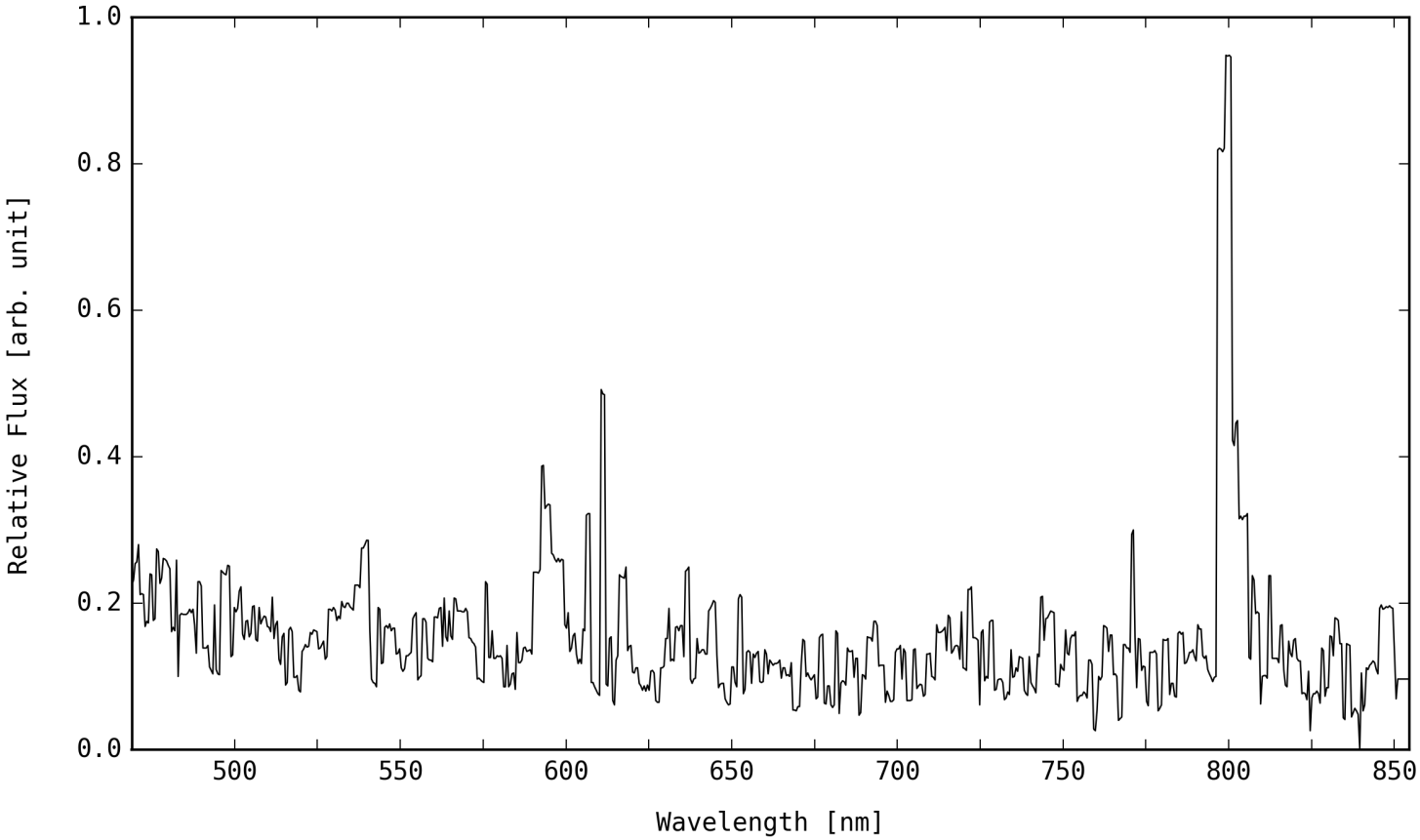
	Distance	**Orbital Period**
Mercury	0.39 AU	88 days
Venus	0.72 AU	225 days
Earth	1.00 AU	365 days
Mars	1.52 AU	687 days

(a) Calculate the average distance of Mercury, Venus and Mars to the Earth.
Which one of these planets is the closest to Earth on average?
(b) Calculate the average distance of Mercury, Venus and Earth to Mars.
Which one of these planets is the closest to Mars on average?
(c) What do you expect for the other planets?

Hint: *Assume circular orbits and use symmetries to make the distance calculation easier. You can approximate the average distance by using four well-chosen points on the planet's orbit.*

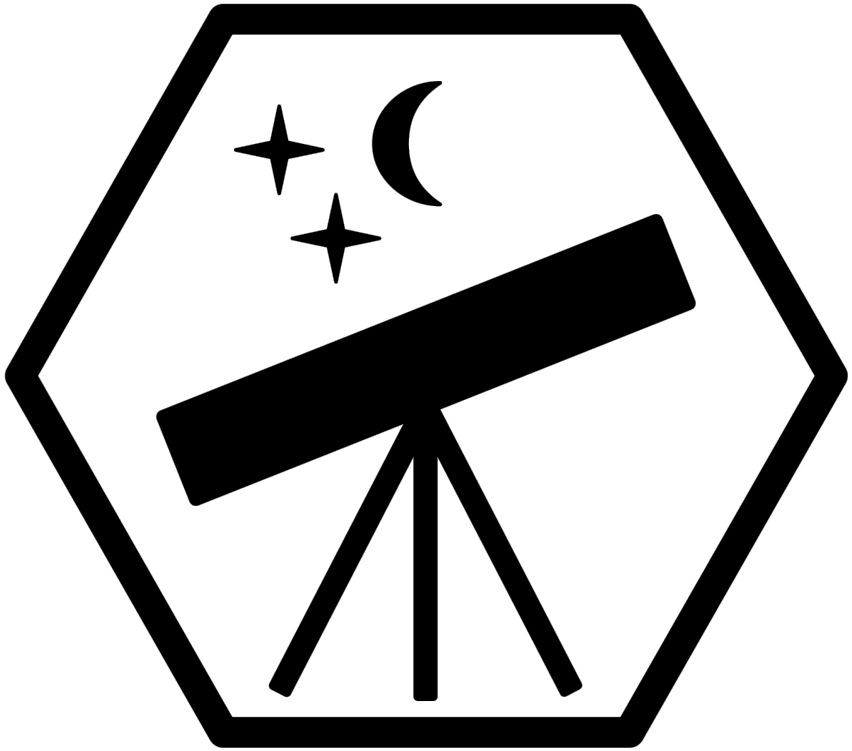
Problem: 2020-PF-B (Part 1)

Your research team analysis the light of a mysterious object in space. By using a spectrometer, you can observe the following spectrum of the object. The Hα line peak is clearly visible:



Problem: 2020-PF-B (Part 2)

(a) Mark the first four spectral lines of hydrogen (Hα, Hβ, Hγ, Hδ) in the spectrum.
(b) Determine the radial velocity and the direction of the object's movement.
(c) Calculate the distance to the observed object.
(d) What possible type of object is your team observing?



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