International Astronomy and Astrophysics Competition
Qualification Round 2019

Moustafa Ashraf
Alexandria STEM School

Problem A: Planets and stars

(1) 8.3 minutes

(2) Lunar eclipse

(3) Jupiter

(4) Mercury

(5) 88

(6) Sirius

(7) 100 (usually between 100-400)

(8) Andromeda

Problem B: The size of Jupiter

(a) $$\text{Volume} = \frac{4}{3}\pi r^3$$

$$\frac{\text{Volume of Jupiter}}{\text{Volume of Earth}} = \frac{\frac{4}{3}\pi {R_j}^3}{\frac{4}{3}\pi {R_e}^3} = \frac{{R_j}^3}{{R_e}^3}$$

$$\frac{70000^3}{6371^3} = 1326.39$$

1326.39 Earths fits into Jupiter by volume

(b) $$\frac{\text{Mass of Jupiter}}{\text{Mass of Earth}} = \frac{\frac{4}{3}\pi {R_j}^3 \rho_j}{\frac{4}{3}\pi {R_e}^3 \rho_e}$$

$$\frac{\frac{4}{3} \times 3.14 \times 70{,}000{,}000^3 \times 1326}{\frac{4}{3} \times 3.14 \times 6371000^3 \times 5514} = \frac{1.90 \times 10^{27} Kg}{5.97 \times 10^{24} Kg}$$

$$= 318.26$$

Jupiter is **318.26** times heavier than Earth

Problem C: Space race to the moon

$$d = v_o t + \frac{1}{2} a t^2$$

Alice case

$$384000 = 500\,t + \frac{1}{2} \times 0 \times t^2$$

$$t = 384000 \div 500 = \mathbf{768}\ hours$$

Bob case

$$384000 = 0\,t + \frac{1}{2} \times 1.4 \times t^2$$

$$t = \sqrt{384000 \times 2 \div 1.4} = \mathbf{740}\ hours$$

Bob took shorter time to reach than Alice

Bob wins this space race.

* this calculation applied if we neglect gravitational force but if we put it in consider neither of them will reach because of high escape velocity needed.*

Problem D: Forces between Earth and Moon

(a) *Lagrange point L1 is the point at which gravity of moon and earth so the net force is zero so* F*(*r*)= 0 so,*

$$\because mG\left(\frac{M_E}{r^2}-\frac{M_M}{(d-r)^2}\right)=0$$

$$\therefore \left(\frac{M_E}{r^2}-\frac{M_M}{(d-r)^2}\right)=\frac{0}{mG}=0$$

$$\therefore \frac{M_E}{r^2}=\frac{M_M}{(d-r)^2} \qquad \therefore \frac{M_E}{M_M}=\frac{r^2}{(d-r)^2}$$

$$\therefore \frac{M_E}{M_M}=\left(\frac{r}{d-r}\right)^2 \qquad \therefore \sqrt{\frac{M_E}{M_M}}=\frac{r}{d-r}$$

$$\therefore (d-r)\sqrt{\frac{M_E}{M_M}}=r \qquad \therefore \left(\frac{d}{r}-1\right)\sqrt{\frac{M_E}{M_M}}=1$$

$$\therefore \frac{d}{r}\sqrt{\frac{M_E}{M_M}}-\sqrt{\frac{M_E}{M_M}}=1$$

$$\therefore \frac{d}{r}\sqrt{\frac{M_E}{M_M}}=1+\sqrt{\frac{M_E}{M_M}}$$

$$\therefore \frac{d}{r} = \frac{1+\sqrt{\frac{M_E}{M_M}}}{\sqrt{\frac{M_E}{M_M}}} \qquad \therefore \frac{1}{r} = \frac{1+\sqrt{\frac{M_E}{M_M}}}{d\sqrt{\frac{M_E}{M_M}}}$$

$$\therefore r = \frac{d\sqrt{\frac{M_E}{M_M}}}{1+\sqrt{\frac{M_E}{M_M}}} \qquad \therefore r = \frac{d\frac{\sqrt{M_E}}{\sqrt{M_M}}}{\frac{\sqrt{M_M}}{\sqrt{M_M}}+\frac{\sqrt{M_E}}{\sqrt{M_M}}}$$

$$\therefore r = \frac{d\frac{\sqrt{M_E}}{\sqrt{M_M}}}{\frac{\sqrt{M_M}+\sqrt{M_E}}{\sqrt{M_M}}} \qquad \boxed{\therefore r = \frac{d\sqrt{M_E}}{\sqrt{M_M}+\sqrt{M_E}}}$$

And this is the formula which gives us the distance to L1 from center of Earth

(b)By assuming they are in rest we mislead the change in the distance due to the elliptical path and miss the centripetal force due to the angular motion.

Problem E: Polar Lights

Converting the disaster of the Solar wind to the beautiful phenomenon of the polar lights (Aurora) is awesome as the **magnetic fields** of the earth deflects the **charged particles** from the sun and collides it with gaseous particles in our atmosphere.

First, free charged particles called the solar wind are thrown from the sun's atmosphere by the rotation of the sun and escape through holes in its magnetic field since the high temperature and the frequent collisions between gases molecules at the sun’s corona (with kinetic energy between 0.5 and 10 keV).

Then the solar wind travels its 8 light minute distance to the earth that takes from 3 to 4 days for it to reach and then it interacts with the atmosphere high in a range from 80 kilometers to as high as 640 kilometers above surface.

The polar lights phenomenon is actually the result of collisions among gases in the atmosphere and charged particles (protons, electrons, alpha and some heavy ions) released from the sun's atmosphere in form of the solar wind. Variations in color are due to the type of gas particles that are colliding. The most common aurora color is yellowish-green that is produced by oxygen about 60 miles above the earth. Rare, most red auroras are produced by oxygen in high attitudes (up to 200 miles) and blue is produced by Nitrogen.