Problem A: Planets and Stars (5 points)

(1.) **8.32 light minutes**

Distance of Earth to the sun = 149, 600, 000 km

Speed of Light = 299, 798, 458 m/s = $1.798790748 \times 10^{10}$ m/min

= $1.798790748 \times 10^{7}$ km/min

Solution:

$$149{,}600{,}000 \text{ km} \times \frac{1 \text{ light minute}}{1.798790748 \times 10^{7} \text{ km}} = 8.316698324 \text{ light minutes}$$

(2.) **Solar Eclipse**

(3.) **Jupiter**

(4.) **Mercury**

(5.) **88 Earth days**

Orbital Velocity of Mercury = 47.362 km/s

Average distance of Mercury from the sun = 57, 909, 050 km

Circumference of Mercury = 2π(57, 909, 050 km) = 363, 853, 292.1 km

Solution

$$363{,}853{,}292.1 \text{ km} \times \frac{1 \text{ second}}{47.362 \text{ km}} = 7{,}682{,}388.668 \text{ seconds}$$

$$7{,}682{,}388.668 \text{ seconds} \times \frac{1 \text{ day}}{86{,}400 \text{ seconds}} = 88.91653551 \text{ Earth days}$$

(6.) **Sirius A**

(7.) **100-400**

(8.) **Andromeda**

Problem B : The Size of Jupiter (5 points)

(a.) Approximately, 1,300 Earths can fit into Jupiter.

Given:

$R_E \approx 6,371\ km$

$R_J \approx 70,000\ km$

Solution:

$V_{sphere} = \frac{4}{3}\pi r^3$

let:
V_J = volume of Jupiter
V_E = volume of Earth

$$\frac{V_J}{V_E} = \frac{\frac{4}{3}\pi (70,000\ km)^3}{\frac{4}{3}\pi (6,371\ km)^3} = \frac{(70,000\ km)^3}{(6,371\ km)^3} = 1,326.390201 \text{ Earths}$$

(b.) Jupiter is 318.97 times heavier than Earth.

Given:

$\rho_E = 5.514\ g/cm^3 = 5,514\ kg/m^3$

$\rho_J = 1,326\ kg/m^3$

Solution:

$\rho = \frac{m}{V}$; $m = \rho V$

let:
m_J = mass of Jupiter
m_E = mass of Earth

$$\frac{m_J}{m_E} = \frac{(1,326\ kg/m^3)(70,000\ km)^3}{(5,514\ kg/m^3)(6,371\ km)^3} = 318.9686991$$

Problem C : Space Race to the Moon (5 Points)

Alice

$V = 500$ km/h (constant)
$d = 384{,}000$ km

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$t = \frac{384{,}000 \not{km}}{500 \not{km}/h} = 768 \text{ hours}$$

$$\boxed{t_A = 768 \text{ hours}}$$

Bob

$a = 1.4$ km/h²
$d = 384{,}000$ km

$d = V_i t + 0.5t^2$; $V_i = 0$

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{(2)(384{,}000 \text{ km})}{(1.4 \text{ km}/h^2)}}$$

$t = 740.6560798$

$$\boxed{t_B = 740.66 \text{ hours}}$$

Therefore, even when Bob starts slowly but accelerates constantly at 1.4 km/h², he will win the race.

Problem D: Forces between Earth and Moon (5 Points)

(a). Given

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

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

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

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

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

$$(d-r)\left[\frac{r}{(d-r)} = \sqrt{\frac{M_E}{M_M}}\right](d-r)$$

$$r = \sqrt{\frac{M_E}{M_M}}\,(d-r)$$

$$r = (d)\sqrt{\frac{M_E}{M_M}} - (r)\sqrt{\frac{M_E}{M_M}}$$

$$(r)\sqrt{\frac{M_E}{M_M}} + r = (d)\sqrt{\frac{M_E}{M_M}}$$

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

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

$$\boxed{r = \frac{(d)\sqrt{\frac{M_E}{M_M}}}{\left(\sqrt{\frac{M_E}{M_M}}+1\right)}}$$

(b.) The Earth-Moon system is moving thus L_1, is not stable.

Problem E

The process begins when, on the surface of the sun, solar activity ejects a cloud of gas called a Coronal Mass Ejection (CME). If it reaches Earth, it collides with the Earth's Magnetic Field. It generates currents of charged particles, which flow along lines of magnetic force into the Polar regions. When these charged particles collide with oxygen and nitrogen atoms, it then produces the auroral light.

In conclusion, northern lights are produced from collisions of electrically charged particles from the sun that enter Earth's atmosphere. it causes the electrons to move to a higher energy State until it releases a photon when it drops back to its lower energy state. Hence, producing the northern lights.