Name: Solutions Date: _____ Pd: _____

Accelerated Physics

Mr. Roberts

Orbital Motion / Acceleration due to Gravity Problem Set

1. At a given point above Earth's surface, the acceleration due to gravity is equal to $7.8\ \mathrm{m/s^2}$. What is the altitude of this point above Earth's surface? (M_{earth} = 5.97×10^{24} kg, R_{earth} = 6.38×10^{6} m)

$g = 7.8\ m/s^2$

$M_E = 5.97 \times 10^{24}$ kg

$R_E = 6.38 \times 10^{6}$ m

Altitude = ?

$g = \frac{GM_E}{d^2}$

$7.8 = \frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{d^2}$

$d = 7145009.017$

$d = R_E + Alt$

$7145009.017 = 6.38 \times 10^{6} + Alt$

$Alt. = 7145009.017 - 6.38 \times 10^{6}$

Alt = 765009.0165 m

2. In another solar system, a planet has an airless moon Zygo that is 4.0×10^{5} m in diameter. Experiments reveal that a freely falling object at the surface of Zygo accelerates at 0.20 m/s^2. What is the mass of Zygo?

distance $= \frac{4.0 \times 10^{5}}{2} = 2 \times 10^{5}$

$g = \frac{GM}{d^2}$

$0.2 = \frac{(6.67 \times 10^{-11})M}{(2 \times 10^{5})^2}$

$M = 1.2 \times 10^{20}$ kg

3. The mass of Pluto is 1.31×10^{22} kg and its radius is 1.15×10^{6} m. What is the acceleration of a freely-falling object at the surface of Pluto if it has no atmosphere?

$g = ?$

$M_p = 1.31 \times 10^{22}$ kg

(d) $R_p = 1.15 \times 10^{6}$ m

$g = \frac{GM_p}{d^2}$

$g = \frac{(6.67 \times 10^{-11})(1.31 \times 10^{22})}{(1.15 \times 10^{6})^2}$

$g = 0.66\ m/s^2$

Weight = mg

4. What's the weight of a 55 kg astronaut aboard a space station orbiting 550 km above the surface of the Earth? Assume the Earth has a mass of 5.97×10^{24} kg, and a radius of 6.38×10^{6} m.

$M_A = 55\text{kg}$

Altitude $= 550\text{km} = 550{,}000\text{m}$

$M_E = 5.97\times10^{24}\text{kg}$

$R_E = 6.38\times10^{6}\text{m}$

$g = \frac{GM}{d^2}$

$d = 6.38\times10^{6} + 550{,}000$

$d = 6930000$

$g = \frac{(6.67\times10^{-11})(5.97\times10^{24})}{(6930000)^2}$

$g = 8.29\ \text{m/s}^2$

Weight $= mg$

$= (55)(8.29) = \boxed{456\text{N}}$

5. The captain of a spaceship orbiting planet X discovers that to remain in orbit at 410 km from the planet's center, she needs to maintain a speed of 68 m/s What is the mass of planet X?

$d = 410\text{km} = 410{,}000\text{m}$

$v = 68\ \text{m/s}$

$M = ?$

$v = \sqrt{\frac{GM}{d}}$

$68 = \sqrt{\frac{(6.67\times10^{-11})(M)}{410{,}000}}$

$\boxed{M = 2.84\times10^{19}\ \text{kg}}$

6. Find the orbital speed of an ice cube in the rings of Saturn. The mass of Saturn is 5.68×10^{26} kg, and use an orbital radius of 1.00×10^{5} km.

$M_S = 5.68\times10^{26}\ \text{kg}$

$d = 1.00\times10^{5}\ \text{km}$

$= 1.00\times10^{8}\text{m}$

$v = ?$

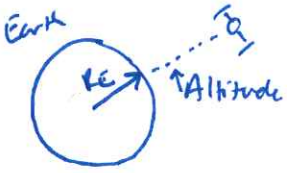
$v = \sqrt{\frac{GM_S}{d}}$

$v = \sqrt{\frac{(6.67\times10^{-11})(5.68\times10^{26})}{1\times10^{8}}}$

$\boxed{v = 19464.2\ \text{m/s}}$

7. The International Space Station is orbiting at an altitude of about 370 km above the earth's surface. The mass of the earth is 5.97×10^{24} kg, the radius of the earth is 6.38×10^{6} m

   a. What is the speed of the ISS in its orbit?



Alt. = 370 km = 370,000 m

$M_E = 5.97 \times 10^{24}$ kg

$R_E = 6.38 \times 10^{6}$

$v = ?$

$$v = \sqrt{\frac{GM_E}{d}}$$

$$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{6750000}}$$

$d = R_E + \text{Altitude}$

$d = 6.38 \times 10^{6} + 370{,}000$

$d = 6750000$ m

$$\boxed{v = 7680.65 \text{ m/s}}$$

   b. What is the period of the ISS orbit?

$v = 7680.65$

$T = ?$

$r = d = 6750000$

$$v = \frac{2\pi r}{T}$$

$$7680.65 = \frac{2\pi (6750000)}{T}$$

$$\boxed{T = 5521.86 \text{ s}} = 1.5 \text{ hours}$$

8. The planet Venus has a mass of 4.87×10^{24} kg and orbits the sun at a distance of ~~1.08x10^8 meters~~ 1.08×10^{8} km $= 1.08 \times 10^{11}$ m. If the Sun has a mass of 1.99×10^{30} kg, calculate...

   a. the orbital speed of Venus in orbit around the Sun

$M_V = 4.87 \times 10^{24}$ kg

$d = 1.08 \times 10^{11}$ m

$M_S = 1.99 \times 10^{30}$ kg

$v = ?$

$$v = \sqrt{\frac{GM_S}{d}}$$

$$v = \sqrt{\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{1.08 \times 10^{11}}}$$

$$\boxed{v = 35057.23 \text{ m/s}}$$

   b. the orbital period of Venus.

$r = d = 1.08 \times 10^{11}$

$$v = \frac{2\pi r}{T}$$

$$35057.23 = \frac{2\pi (1.08 \times 10^{11})}{T}$$

$$\boxed{T = 19356464.08 \text{ s}} = 224 \text{ days}$$