UNIVERSAL GRAVITATION - SOLUTIONS

1. GIVEN:

$m_1 = 6.0\ kg$
$m_2 = 8.0\ kg$
$r = 2.0\ m$
$F_g = ?$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$= (6.67\times10^{-11})\frac{(6.0)(8.0)}{(2.0)^2}$$

$$= 8.0\times10^{-10}\ N$$

2. GIVEN:

$m_1 = m_2 = m$
$r = 30.\ m$
$F_g = 2.0\times10^{-7}\ N$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$= G\frac{m^2}{r^2}$$

$$m = \sqrt{\frac{F_g r^2}{G}}$$

$$= \sqrt{\frac{(2.0\times10^{-7})(30.)^2}{(6.67\times10^{-11})}}$$

$$= 1600\ kg$$

3. $F_g \propto \frac{1}{r^2}$ (PROPORTIONAL TO)

F_g IS INVERSELY PROPORTIONAL TO THE SQUARE OF THE RADIUS

IF r IS INCREASED BY A FACTOR OF 10, THEN F_g IS DECREASED BY A FACTOR OF $\frac{1}{10^2}$

$$700\times\frac{1}{100} = 7\ N$$

4. a) $F_g = mg$

$= (1.0 \times 10^5)(9.8)$

$= 9.8 \times 10^5$ N

b) GIVEN:

$M_1 = M_E = 5.98 \times 10^{24}$ kg

$M_2 = 1.0 \times 10^5$ kg

$r = 128\,000$ km $= 128\,000\,000$ m

$F_g = ?$

$F_g = G\frac{M_1 M_2}{r^2}$

$= (6.67 \times 10^{-11})\frac{(5.98 \times 10^{24})(1.0 \times 10^5)}{(128\,000\,000)^2}$

$= 2400$ N

c) GIVEN:

$M_1 = M_E = 5.98 \times 10^{24}$ kg

$M_2 = 1.0 \times 10^5$ kg

$r = 384\,000$ km $= 384\,000\,000$ m

$F_g = ?$

$F_g = G\frac{M_1 M_2}{r^2}$

$= (6.67 \times 10^{-11})\frac{(5.98 \times 10^{24})(1.0 \times 10^5)}{(384\,000\,000)^2}$

$= 270$ N

d) GIVEN:

$M_1 = M_E = 5.98 \times 10^{24}$ kg

$M_2 = 1.0 \times 10^5$ kg

$r = 1.5 \times 10^8$ km $= 1.5 \times 10^{11}$ m

$F_g = ?$

$F_g = G\frac{M_1 M_2}{r^2}$

$= (6.67 \times 10^{-11})\frac{(5.98 \times 10^{24})(1.0 \times 10^5)}{(1.5 \times 10^{11})^2}$

$= 0.0018$ N

5. a) GIVEN:

$m_1 = M_E = 5.97 \times 10^{24}\ kg$

$m_2 = 60.0\ kg$

$r = 6356\ km = 6356000\ m$

$F_g = ?$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$= (6.67 \times 10^{-11})\frac{(5.97 \times 10^{24})(60.0)}{(6356000)^2}$$

$$= 591\ N$$

ANSWERS WILL VARY

b) GIVEN:

$m_1 = M_E = 5.97 \times 10^{24}\ kg$

$m_2 = 60.0\ kg$

$r = 6378\ km = 6378\ 000\ m$

$F_g = ?$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$= (6.67 \times 10^{-11})\frac{(5.97 \times 10^{24})(60.0)}{(6378\ 000)^2}$$

$$= 587\ N$$

ANSWERS WILL VARY

c) $$\text{PERCENT DIFFERENCE} = \frac{|F_{g_1} - F_{g_2}|}{\left(\frac{F_{g_1} + F_{g_2}}{2}\right)}$$ ← AVERAGE OF F_{g_1} AND F_{g_2}

$$= \frac{|591 - 587|}{\left(\frac{591 + 587}{2}\right)}$$

$$= 0.00691 = 0.691\%$$

d) 0 MASS DOES NOT DEPEND ON THE GRAVITATIONAL FIELD STRENGTH.

6. a) GIVEN:

$M = 6.39 \times 10^{23}\ kg$

$r = 3390\ km = 3390000\ m$

$g = ?$

$g = G\frac{M}{r^2}$

$= (6.67 \times 10^{-11})\frac{(6.39 \times 10^{23})}{(3390000)^2}$

$= 3.71 \frac{N}{kg}$

38% OF THE GRAVITATIONAL FIELD STRENGTH ON EARTH.

b) $F_g = mg_{MARS}$

$= (60.0)(3.71)$

$= 223\ N$ ANSWERS WILL VARY

7. KINEMATICS

GIVEN:

$v_i = 0$

$v_f = 15 \frac{m}{s}$

$t = 5.0\ s$

$a = ?$

$v_f = v_i + at$ ($v_i \to 0$)

$v_f = at$

$a = \frac{v_f}{t}$

$= \frac{15}{5.0}$

$= 3.0 \frac{m}{s^2}$

GIVEN:

$g = a = 3.0 \frac{N}{kg}$

$r = 6.38 \times 10^6\ m$

$m = ?$

$g = G\frac{m}{r^2}$

$m = \frac{gr^2}{G}$

$= \frac{(3.0)(6.38 \times 10^6)^2}{(6.67 \times 10^{-11})}$

$= 1.8 \times 10^{24}\ kg$

8.

GIVEN:

$r = 1.74 \times 10^6$ m

$m = 7.35 \times 10^{22}$ kg

$g = ?$

$$g = G\frac{m}{r^2}$$

$$= (6.7 \times 10^{-11})\frac{(7.35 \times 10^{22})}{(1.74 \times 10^6)^2}$$

$$= 1.62 \frac{m}{s^2}$$

KINEMATICS

GIVEN:

$v_i = 3.2 \frac{m}{s}$

$v_f = 0$

$a = g_{MOON} = -1.62 \frac{m}{s^2}$ ← NEGATIVE SINCE WE ARE TAKING UP TO BE POSITIVE

$d = ?$

$v_f^2 = v_i^2 + 2ad$ (0)

$0 = v_i^2 + 2ad$

$$d = -\frac{v_i^2}{2a}$$

$$= -\frac{(3.2)^2}{2(-1.62)}$$

$$= 3.2 \text{ m}$$