Review Unit 02—Gravitation and Circular Motion

1. What is the **force of gravity** between Jupiter and a 60.0 kg mass on Jupiter's surface? The mass of Jupiter is 1.90 E 27 kg and its radius is 7.15 E 7 m.

$$F_G = \frac{GM_1M_2}{R^2} = \frac{(6.67\times10^{-11})(60)(1.90\times10^{27})}{(7.15\times10^{7}\,m)^2}$$

$\boxed{1487\ N}$

2. Mars has a mass of 6.4 E 23 kg and a radius of 3.40 E 6 m. What is the **acceleration due to gravity** on the surface of Mars?

$$g = \frac{GM_1}{R^2} = \frac{(6.67\times10^{-11}\ N\cdot m^2/kg^2)(6.4\times10^{23}\ kg)}{(3.40\times10^{6}\,m)^2}$$

$\boxed{3.69\ m/s^2}$

3. A waterwheel built in Hamah, Syria, rotates continuously. The wheel's radius is 18 meters. If the wheel makes one revolution in 15 seconds, what is the centripetal acceleration of the wheel's edge?

$r = 18m$

$T = 15 s/rev$

$a_c = ?$

$$a_c = \frac{4\pi^2 r}{T^2} = \frac{4(\pi^2)(18m)}{(15s)^2} = 3.16\ m/s^2$$

$\boxed{3.16\ m/s^2}$

4. A 0.25 kg ball is swinging in a **horizontal** circle at the end of a string 0.75 meters long. If the string breaks when the ball is swung at 139 **RPM**, what is the maximum tension the string can withstand?

$m = 0.25\ kg$

$\boxed{m} \longrightarrow F_t$

$r = 0.75m$

$$\frac{1}{139\ RPM} \times \frac{60s}{1\ min} = 0.43\ s/rev$$

$F_t = ?$

$$F_t = ma_c = m\frac{4\pi^2 r}{T^2}$$

$$F_t = \frac{(0.25\ kg)(4\pi^2)(0.75m)}{(0.43s)^2}$$

$\boxed{40\ N}$

5. If a car is to round a curve of radius 105 m at a speed of 20 m/s, how large must the coefficient of friction be in order that the car does not skid?

$r = 105m$

$v_c = 20m/s$

$\mu = ?$

F_N, F_g, $\boxed{m} \longrightarrow F_f = m\cdot g\cdot\mu$

$$F_f = ma_c = m\frac{v^2}{r}$$

$$\cancel{m}\cdot g\cdot\mu = \frac{\cancel{m}\cdot v^2}{r}$$

$$\mu = \frac{v^2}{rg}$$

$$\mu = \frac{(20m/s)^2}{(105m)(9.8m/s^2)}$$

$\boxed{0.39}$

6. A 0.24 kg ball is swung in a vertical circle on the end of a string 0.80 meters long. If the ball's velocity is 7.4 m/s, what is the tension in the string at the **top** of the swing?

$m = 0.24\,kg$ $r = 0.80\,m$ $V_c = 7.4\,m/s$

$+F_g + F_t = +ma_c$

$m \cdot g + F_t = m\frac{v^2}{r}$

$F_t = \frac{mv^2}{r} - m \cdot g$

$F_t = \frac{(0.24)(7.4)^2}{(0.80)} - (0.24)(9.8)$

$\boxed{14.076\ N}$

7. When a 0.14 kg ball is swung in a vertical circle on a string 0.62 m long, the tension in the string at the **bottom** of the swing is 10.2 N. What is the velocity of the ball?

$m = 0.14\,kg$

$F_t - F_g = ma_c$

$F_t - m \cdot g = m \cdot \frac{v^2}{r}$

$10.2 - (0.14)(9.8) = (0.14)\left(\frac{v^2}{0.62}\right)$

$8.828 = \frac{0.14}{0.62} \cdot v^2$

$v^2 = (8.828)\left(\frac{0.62}{0.14}\right)$

$v = \sqrt{39.095}$

$\boxed{6.25\,m/s}$

8. The seat of the roller coaster applies a force of 150 N on your rear end at the **top** of a loop when the roller coaster is traveling at 23 m/s. Assuming your mass is 58 kg, what is the radius of the loop?

$F_N = 150N$ $V_c = 23\,m/s$ $m = 58\,kg$ $r = ?$

$-F_N - F_g = -ma_c$

$(-150) - (58)(9.8) = -(58)\left(\frac{v^2}{r}\right) = \frac{(-58)(23)^2}{r}$

$-718.4 = \frac{-30682}{r}$

$r = \frac{+30682}{+718.4}$

$\boxed{42.71\ m}$

9. On a roller coaster a 50 kg passenger rides in a loop of radius 18.0 m traveling at 11 m/s. How much force does the seat apply to the passenger's rear end when the coaster is at the **bottom** of the loop?

$m = 50\,kg$ $r = 18.0\,m$ $V_c = 11\,m/s$ $F_N = ?$

$F_N - F_g = ma_c = \frac{mv^2}{r}$

$F_N - (50)(9.8) = \frac{(50)(11)^2}{18}$

$F_N - 490 = 336.1$

$F_N = 336.1 + 490$

$\boxed{826.1\ N}$

10. When going 33 m/s over a smoothly rounded hill, you feel weightless. What is the radius of the hill?

means $F_N = 0$

$V_c = 33\,m/s$ $F_N = 0$ $r = ?$

$-F_g = ma_c$

$+\cancel{m} \cdot g = +\cancel{m} \cdot \frac{v^2}{r}$

$g = \frac{v^2}{r}$

$9.8 = \frac{(33)^2}{r}$

$r = \frac{1089}{9.8}$

$\boxed{111.12\ m}$

Review your notes and the online notes. Make sure you understand the concepts related to the Universal Law of Gravity and Circular Motion. The test will be multiple choice. Some questions will involve problem solving.