CH # 7 CIRCULAR MOTION AND GRAVITATION

Some important formulae:

i) $a_c = \frac{V^2}{r}$ ii) $F_c = \frac{mV^2}{r}$ $iii)$ F = $G\frac{m_1 m_2}{r^2}$

7.1: At what speed must an object travels in a circle of radius 2m to experience a centripetal acceleration of 9.8m/s^2.

GIVEN:
Centripetal acceleration = a_c = 9.8m/s^2
Radius of object = r = 2m

REQUIRED:
Speed of object = V = ?

SOLUTION:
$a_c = \frac{V^2}{r}$
$V^2 = a_c$ x r
V^2 = 9.8 x 2
V^2 = 19.6
By taking square root on both sides,
V = $\sqrt{19.6}$
V = 4.427 m/s

7.2: A car goes round a curve at 20m/s. The radius of curvature is 50m. Calculate the centripetal acceleration of the car.

GIVEN:
Speed of car = m = 20m/s
Radius of curvature = r = 50m

REQUIRED:
Centripetal acceleration = a_c = ?

SOLUTION:
$a_c = \frac{V^2}{r}$
$a_c = \frac{(20)^2}{50}$
$a_c = 8\text{m/s}^2$

7.3: A proton of mass 1.67 x 10^{-27}Kg is moving in a circle of radius 100cm. An electro-magnet applies a force of 1 x 10^{-12}N directed towards the center of the circle. What is the velocity of the proton?

GIVEN:
Mass of proton = m 1.67 x 10^{-27}Kg
Radius = r = 100cm = 1m
Force = F = 1 x 10^{-12}N

REQUIRED:
Velocity of proton = ?

SOLUTION:
$F_c = \frac{mv^2}{r}$
$V^2 = \frac{F_c r}{m}$
$V^2 = \frac{1\text{ x }10^{-12} \times 1}{1.67\text{ x }10^{-27}}$
V^2 = 6 x 10^{14}
By taking square root on both sides,
V = $\sqrt{6\text{ x }10^{14}}$
V = 2.44 x 10^{7}m/s

7.4: A string 2m long is used to whirl a 200mg stone in horizontal circle at a speed of 2m/s. Find tension in string.

GIVEN:
Mass of stone = m = 200gm = 200/1000 = 0.2Kg
Speed = V = 2m/s
Radius = r = 2m

REQUIRED:
Tension in string = F = ?

SOLUTION:
$F_c = \frac{mv^2}{r}$
$F_c = \frac{(0.2)(2)^2}{2}$
F_c = 0.4N

7.5: Compute the gravitational force of attraction between two boys of masses 50Kg and 40Kg respectively apart from each other.

GIVEN:
Mass of first boy = m_1 = 50Kg
Mass of second boy = m_2 = 40Kg
Gravitational constant = G = 6.67 x 10^{-11} Nm^2/Kg^2

REQUIRED:

Gravitational force between the boys = F = ?

SOLUTION:

$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{6.67 \times 10^{-11} \times 50 \times 40}{(1)^2}$$

F = 13.34 x 10^{-8}N

7.6: Compute the force of gravitation between the large and small spheres of Cavendish balance if m = 1gm and M= 300gm and r = 5cm.

GIVEN:

Mass of small sphere = m = 1gm

Mass of large sphere = M = 300gm

Distance between the spheres = r = 5cm

Value of gravitation constant = G = 6.67 x 10^{-8}Dyn.cm^2/gm^2

REQUIRED:

Gravitational force = F = ?

SOLUTION:

$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{6.67 \times 10^{-8} \times 1 \times 300}{(5)^2}$$

F = 8.004 x 10^{-7}Dyn

7.7: Two balls of 40Kg and 20Kg masses attract each other with force of 3.33 x 10^{-7}N. Find the distance between the masses if the value of G = 6.67 x 10^{-11} Nm^2/Kg^2.

GIVEN:

Mass of First ball = m_1 = 40Kg

Mass of 2nd ball = m_2 = 20Kg

Gravitational force between balls = F = 3.33 x 10^{-7}N

Value of gravitation constant = G = 6.67 x $10^{-11}$$Nm^2/Kg^2$

REQUIRED:

Distance between the balls = r = ?

SOLUTION:

$$F = \frac{Gm_1m_2}{r^2}$$

$$r^2 = \frac{Gm_1m_2}{F}$$

$$r^2 = \frac{6.67 \text{ x } 10^{-11} \times 40 \times 50}{3.33 \times 10^{-7}}$$

r^2 = 0.1602

By taking square root on both sides,

r = $\sqrt{0.1602}$

r = 0.4 m

7.8: The distance from the earth to sun is 1.49 x 10^{11}m. The mass of earth is 6 x 10^{24}Kg and mass of sun is 2 x 10^{30}Kg compute the gravitational force between them.

GIVEN:

Mass of the earth = Me = 6 x 10^{24}Kg

Mass of sun = Ms = 2 x 10^{30}Kg

Distance between the sun to the earth = r = 1.49 x 10^{11}m

Value of gravitation constant = G = 6.67 x $10^{-11}$$Nm^2/Kg^2$

REQUIRED:

Gravitational force = F = ?

SOLUTION:

$$F = \frac{Gm_em_S}{r^2}$$

$$F = \frac{6.67 \text{ x } 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{(1.49 \times 10^{11})^2}$$

F = 3.6 x 10^{22} N