FBISE 9th Class Physics New Book Notes

Chapter 4

NUMERICAL RESPONSE QUESTIONS

Q1. Calculate the torque acting on spanner of length 20 cm to loosen a nut by a force of 50 N. If the same nut is to be loosen up by force of 100 N, what should be length of spanner? (Ans. 10Nm and 10 cm)

Solution:

Glven data:
Length of spanner $d_1 = \mathbf{20\ cm} = 0.2$ m
Force $F_1 = \mathbf{50\ N}$
Force $F_2 = \mathbf{100}$N

Required:
$\tau_1 = ?$
Length of spanner $d_2 = ?$
$\Rightarrow \tau_1 = d_1 \times F_1 = 0.2 \times 50 = 10$Nm
To loosen the same nut, both the spanners must produce equal torques, given by:

$$\tau_1 = \tau_2 \Rightarrow d_1 \times F_1 = d_2 \times F_2 \Rightarrow d_2 = \frac{d_1 \times F_1}{F_2}.$$

Putting values: $d_2 = \frac{0.2\times50}{100} \Rightarrow d_2 = 0.1\text{ m} = 10\text{ cm}$

Q2. A long uniform steel bar of length 1.0 m is balanced by a pivot at its middle. Two mass m_1 and m_2 are suspended at a distance of 0.2 m and 0.3 m respectively from the plvot. Ignoring mass of the steel bar, if mass

$m_1 = 0.6$ kg find mass m_2. (Ans. 0.4 kg)
Solution:
Given data: Moment arm of $m_1, d_1 = 0.2$ m
Moment arm of m_2, $d_2 = \mathbf{0.3}$m
Mass $m_1 = 0.6$ kg
Required: Mass $m_2 = ?$
By second condition of equilibrium,

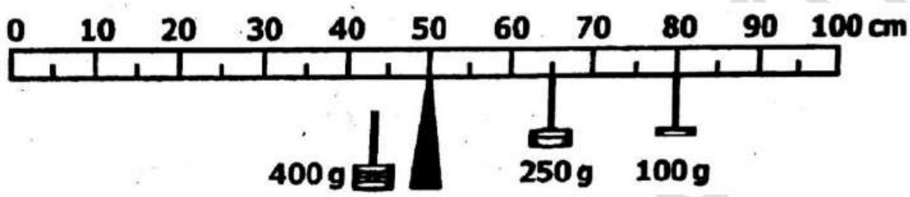
$$\boldsymbol{\tau}_{\text{anticlockwise}} = \boldsymbol{\tau}_{\text{clockwise}} \text{ or } \boldsymbol{\tau_1} = \boldsymbol{\tau_2}$$

Hence, $d_1 \times w_1 = d_2 \times w_2$
As, weight of a body can be given by $\mathbf{w} = mg$.
Putting in above equation,

$$d_1 \times m_1 g = d_2 \times m_2 g \Rightarrow m_2 = \frac{d_1 \times m_1 g}{d_2 \times g}$$

Therefore, $m_2 = \frac{0.2 \text{ m} \times 0.6 \text{ kg}}{0.3 \text{ m}} \Rightarrow m_2 = 0.4 \text{ kg}$

Q3. Two masses, 250 g and 100 g, are hanging at positions 65 cm and 80,cm, respectively, on a on a uniform meter rod, pivoted at 50 cm mark as shown. Where should a third mass of 400 g be positioned to balance the rod? (Ans. 16.875 cm)



Solution:
Given data: Mass m_1 = **250**g; Mass m_2 = **100**g; Mass m_3 = **400**g

Position of pivot point = **50**cm

Position of m_1 = **80**cm
Position of m_2 = 65 cm

Required: position of = d_3 **?**
First we will find moment arms of m_1 and m_2.
Moment arm of m_1 mass $d_1 = 80 - 50 = \mathbf{30}$cm
Moment arm of m_2 mass $d_2 = 65 - 50 = 15$ cm
Mass m_3 will be positioned on the left side of the pivot point to balance the meter rod.
From principle of moments, clockwise torques are equal to anticlockwise torques:

tuyt

$$\Rightarrow \tau_{\text{clockwise}} = \tau_{\text{anticlochwise}} \Rightarrow d_3 \times F_3 = (d_1 \times F_1) + (d_2 \times F_2)$$

$$\Rightarrow d_3 \times m_3 g = (d_1 \times m_1 g) + (d_2 \times m_2 g)$$

$$\Rightarrow d_3 \times m_3 = (d_1 \times m_1) + (d_2 \times m_2)$$

$$\Rightarrow d_3 = \frac{(d_1 \times m_1) + (d_2 \times m_2)}{m_3}$$

Putting values,

$$\Rightarrow d_3 = \frac{(30 \times 100) + (15 \times 250)}{400} = \frac{3000 + 3750}{400} = \frac{6750}{400}$$

$$\Rightarrow d_3 = 16.875 \text{ cm}$$

Q4. A car welghing 1200 kg enters a roundabout with a diameter of 60 meters at a speed of 25kmh^{-1}. Calculate the centripetal force acting on the car as it navigates the curve.

(Ans. 1926.54 N)

Solution:

Glven data: Mass of the car, $m = 1200$ kg

Diameter of the roundabout, $\mathrm{d} = 60$ m

Speed of the car, $v = 25\text{kmh}^{-1}$

Required: Centripetal force $\mathbf{F}_c = ?$

First, let's convert the speed of the car from kilometers per hour (kmh^{-1}) to metera per second (ms^{-1}):

$$\Rightarrow \text{ Speed} = v = 25\mathbf{kmh}^{-1} = \frac{25 \times 1000}{3600} \text{ ms}^{-1}$$

$$\Rightarrow \text{ Speed} = v \approx 6.94 \text{ ms}^{-1}$$

Now, we can find the centripetal force using the formula: $F_c = \frac{mv^2}{r}$

The radius (r) of the circular path is half of the diameter of the roundabout:

$$\Rightarrow r = \frac{d}{2} = \frac{60 \text{ m}}{2} = 30 \text{ m}$$

Now, we can plug in the values into the formula:

$$\Rightarrow F = \frac{1200 \text{ kg} \times (6.94 \text{ ms}^{-1})^2}{30 \text{ m}} \Rightarrow F \approx \frac{1200 \times 48.1636}{30} \text{ N}$$

$$\Rightarrow F \approx \frac{57796.32}{30} \text{ N } \Rightarrow \approx 1926.54 \text{ N}$$

So, the centripetal force acting on the car as it navigates the curve is approximately 1926.54 N.

Q5. A geostationary satellite revolves around earth in an orbit of radius 42000 km. Find orbital speed of the satellite at this height. (Ans. 3.052kms^{-1})

Solution:

Given data: Height = h = $\mathbf{42000}\text{km} = 42000 \times 1000\ \text{m} = 42.0 \times 10^6\ \text{m}$

Radius of earth = $R_\text{E} = 6.4 \times 10^6\ \text{m}$

Mass of earth = $M_E = 6 \times 10^{24}\ \text{kg}$

Gravitational constant = $G = 6.67 \times 10^{-11}\text{Nm}^2\ \text{kg}^{-2}$

Bequired: Orbital speed = $\mathbf{v}$ = ?

The orbital speed is given by: $v = \sqrt{G\frac{M_E}{r}} = \sqrt{G\frac{M_E}{R_E+h}}$

Putting values,

$$v = \sqrt{6.67 \times 10^{-11}\text{Nm}^2\ \text{kg}^{-2} \times \frac{6 \times 10^{24}\ \text{kg}}{(6.4 \times 10^6 + 42.0 \times 10^6)\text{m}}}$$

$$v = \sqrt{6.67 \times 10^{-11}\text{Nm}^2\ \text{kg}^{-2} \times \frac{6 \times 10^{24}\ \text{kg}}{(6.4 + 42.0)10^6\ \text{mm}}}$$

$$v = \sqrt{\frac{6.67 \times 6 \times 10^{24-11-6}\ \text{kg}}{48.4}} = \sqrt{0.83 \times 10^7}$$

$$v = 0.911 \times 10^3\ \text{ms}^{-1} = 2.88\text{kms}^{-1}$$

OR(SecondAnswer)

A geostationary satellite orbits Earth with a period equal to the rotational period of Earth which is $\mathbf{24}$ hours (or 86400 seconds). To find the orbital speed of the satellite, we use the formula for the speed of an object in circular motion:

$$v = \frac{2mr}{T}$$

Where,

- $\mathbf{v}$ is the orbital speed.
- $\mathbf{r}$ is the radius of the orbit.
- $\mathbf{T}$ is the orbital period.

→ Glvendata:

- The radius of the orbit r = $\mathbf{24000}\text{km} = \mathbf{42000} \times \mathbf{103}\text{m}$

- The orbital period $T = 24$ hours $= 24 \times 60 \times 60$ seconds

$$= 86400 \text{ seconds}$$

Now we can calculate the orbital speed.

$$\Rightarrow v = \frac{2\pi r}{T} = \frac{2\pi \times 42000 \times 10^3}{86400} = \frac{2\pi \times 42000}{86.4}$$

$$\Rightarrow v = \frac{2\pi \times 420}{0.864} \Rightarrow v = \frac{840\pi}{0.864} \Rightarrow v = \frac{840 \times 3.14159}{0.864}$$

$$\Rightarrow v \approx \frac{2638.8364}{0.864} \approx 3055.368 \text{ ms}^{-1} \Rightarrow v = 3.055\text{kms}^{-1}$$

The orbital speed of the geostationary satellite at this height is approximately 3.055kms^{-1}.