

Physics

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(Chapter 6) (Systems of Particles and Rotational Motion) (Exercises) (Class 11)

Question 6.14:

To maintain a rotor at a uniform angular speed of 200 rad s^{-1} , an engine needs to transmit a torque of 180 N m . What is the power required by the engine? (Note: uniform angular velocity in the absence of friction implies zero torque. In practice, applied torque is needed to counter frictional torque). Assume that the engine is 100% efficient.

Answer 6.14:

Angular speed of the rotor, $\omega = 200 \text{ rad/s}$

Torque required, $\tau = 180 \text{ Nm}$

The power of the rotor (P) is related to torque and angular speed by the relation:

$$P = \tau\omega = 180 \times 200 = 36 \times 10^3 = 36 \text{ kW}$$

Hence, the power required by the engine is 36 kW .

Question 6.15:

From a uniform disk of radius R , a circular hole of radius $R/2$ is cut out. The centre of the hole is at $R/2$ from the centre of the original disc. Locate the centre of gravity of the resulting flat body.

Answer 6.15:

$R/6$; from the original centre of the body and opposite to the centre of the cut portion.

Mass per unit area of the original disc = σ and Radius of the original disc = R

Mass of the original disc, $M = \pi R^2 \sigma$

The disc with the cut portion is shown in the following figure:

Radius of the smaller disc = $\frac{R}{2}$

$$\text{Mass of the smaller disc, } M' = \pi \left(\frac{R}{2}\right)^2 \sigma = \frac{1}{4} \pi R^2 \sigma = \frac{M}{4}$$

Let O and O' be the respective centres of the original disc and the disc cut off from the original. As per the definition of the centre of mass, the centre of mass of the original disc is supposed to be concentrated at O, while that of the smaller disc is supposed to be concentrated at O'.

It is given that: $OO' = \frac{R}{2}$

After the smaller disc has been cut from the original, the remaining portion is considered to be a system of two masses. The two masses are:

M (concentrated at O), and $-M'$ $\left(-\frac{M}{4}\right)$ concentrated at O'.

(The negative sign indicates that this portion has been removed from the original disc.)

Let x be the distance through which the centre of mass of the remaining portion shifts from point O.

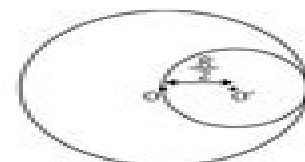
The relation between the centres of masses of two masses is given as: $x = \frac{m_1 r_1 + m_2 r_2}{m_1 + m_2}$

For the given system, we can write:

$$x = \frac{M \times 0 - M' \times \left(\frac{R}{2}\right)}{M + (-M')}$$

$$\Rightarrow x = \frac{-\frac{M}{4} \times \frac{R}{2}}{M - \frac{M}{4}} = \frac{-\frac{MR}{8}}{\frac{3M}{4}} = \frac{-4}{6}$$

(The negative sign indicates that the centre of mass gets shifted toward the left of point O.)



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