Rotational Power, Work, Energy

Tuesday, July 8, 2025 7:08 PM

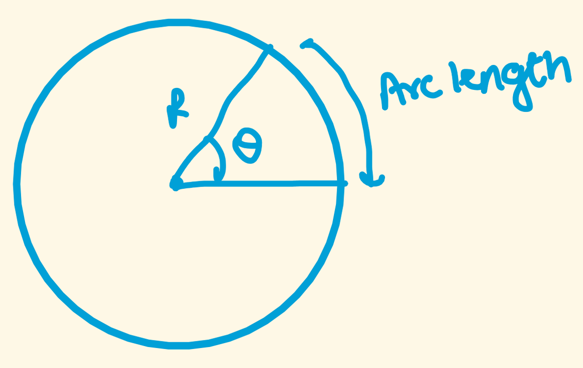
Author: Kumar Anurag

1. Introduction:

We know that,

Linear Work done, $W = \underbrace{F}_{\text{force}} \cdot \underbrace{d}_{\text{displacement}}$

Also, we know that:



From mathematics:

Arc length, $d = R \cdot \theta$

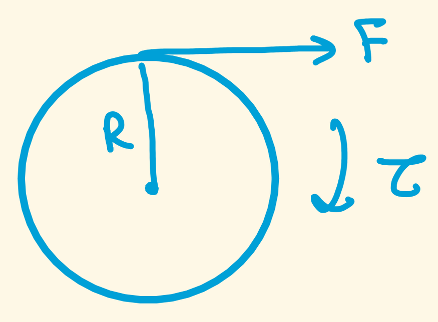
$\Rightarrow \quad W = F \cdot d$

$W = F \cdot (R\theta)$

$= (F \cdot R)\,\theta$

$\boxed{W = \tau \cdot \theta}$

Rotational Work done



Other ways to calculate work done:

$W = \Delta KE \quad$ ($\because$ change in kinetic energy)

$= KE_f - KE_i$

where $KE = \frac{1}{2} m v^2$

Also, $\quad W = \Delta RKE$

$= (RKE)_f - (RKE)_i$

where $RKE = \frac{1}{2} I \omega^2$

POWER

$\boxed{P = \frac{W}{t}}$

$= \frac{F \cdot d}{t}$

$= F \cdot \left(\frac{d}{t}\right)$

$\boxed{P = F \cdot v}$

SI unit of Power = Watt

Power tells us the rate at which the energy is transferred.

1 Watt = 1 $\frac{\text{Joule}}{\text{sec}}$

$P = F \cdot (\omega R)$

$P = (F \cdot R)\,\omega$

$\boxed{P = \tau \cdot \omega}$

ENERGY:

$\boxed{E = P \cdot t}$

1 hp = 746 Watts

hp → horse power

1 kW = 1000 W

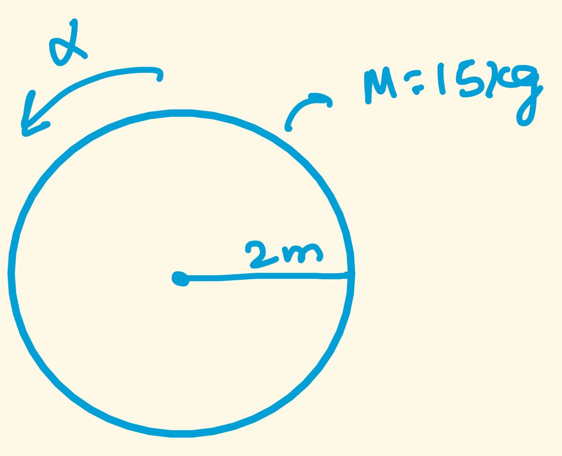
2. Problem:

Problem-01: A 15 kg disc with a radius of 2 m accelerates from rest to 40 rad/s in 5 seconds.

(a) How much work was required to accelerate it to this speed?

(b) Calculate the average power exerted on the disk.

Solution:



$\omega_i = 0$ rad/s

$\omega_f = 40$ rad/s

$t = 5$ seconds

a) $\therefore \quad \omega_f = \omega_i + \alpha t$

$40 = 0 + \alpha(5)$

$\boxed{\alpha = 8 \text{ rad/sec}^2}$

$\therefore \quad W = Fd$

$W = \tau \cdot \theta$

$= (I\alpha) \cdot \left(\omega_0 t + \frac{1}{2} \alpha t^2\right)$

$= (I\alpha) \left(0 + \frac{1}{2}(8)(5)^2\right)$

$= 4\,(I \cdot \alpha)(25)$

$= 100\ I \cdot (8)$

$= 800 \cdot I$

$= 800 \left(\frac{1}{2} MR^2\right)$

$= 800 \left[\frac{1}{2}(15)(2)^2\right]$

$W = 24000\,\text{J}$

$\boxed{W = 24\,\text{kJ}}$

b) $P = \frac{W}{t} = \frac{24}{5} = 4.8\,\text{kW}$

kW → kilowatt

3. References:

1. The Organic Chemistry Tutor

—x— THE END —x—