Angular Impulse

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Author: Kumar Anurag

1. Problems:

* **Example-01:** A force of 10 N is applied to a 5 kg disc with a radius of 70 cm for a time of 8 seconds.

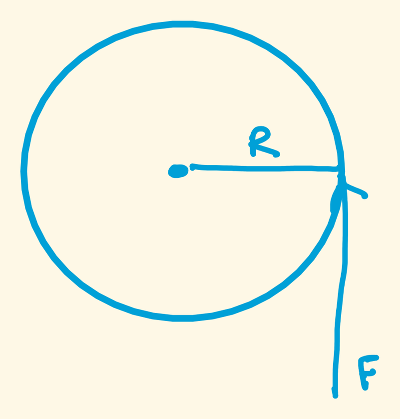
(a) Calculate the torque acting on the disk.

(b) Calculate the angular impulse that was applied on the disk.

(c) What is the change of the angular momentum of the disk?

(d) If the disk was spinning initially at 14.3 rad/s, what is the new angular speed of the disk 8 seconds later?

Solution:



Given:

$F = 10N$

$R = \frac{70}{100} m = 0.7m$

$t = 8$ seconds

$m = 5 kg$

(a) $\tau_{disk} = F \cdot R$

$= (10)(0.7)$

$= 7 \ N \cdot m$

(b) We know that,

Linear Impulse, $I_{linear} = F \cdot \Delta t$

Angular Impulse, $\boxed{I_{angular} = \tau \cdot \Delta t}$

$= 7 \cdot (8)$

$= 56 \ N \cdot m \cdot sec$

(c) We know that,

$\tau_{net} = \frac{\Delta L}{\Delta t}$

$\Delta L = \tau_{net} \cdot \Delta t$

$\Delta L = I_{angular}$

which means, change in angular momentum is equal to the Angular Impulse.

$\Delta L = 56 \ Nm sec$

(d) $\omega_0 = 14.3$ rad/sec

$t = 8$ seconds.

$\tau = I \cdot \alpha \Rightarrow \alpha = \frac{\tau}{I} = \frac{7}{\frac{1}{2}MR^2} = \frac{7(2)}{(5)(0.7)^2}$

$= \frac{14}{5 \cdot (0.7)^2}$

$= 5.714$ rad/sec^2

$\omega_f = \omega_0 + \alpha t$

$= 14.3 + (5.714) 8$

$= 60.014$ rad/sec

Another method:

We know that change in angular momentum is equal to the Angular Impulse.

$\Delta L = I_{angular}$

$I \Delta \omega = \tau \cdot \Delta t$

$I (\omega_f - \omega_0) = \tau \cdot \Delta t$

$\frac{1}{2} MR^2 (\omega_f - \omega_0) = \tau \cdot \Delta t$

$\frac{1}{2} (5)(0.7)^2 (\omega_f - 14.3) = 7 \cdot (8)$

$\omega_f = 14.3 + \frac{56(2)}{5(0.7)^2}$

$= 60.014$ rad/sec.

let's say we want to calculate work done by the force on this disc.

$W = ?$

Method-1:

$W =$ change in Rotational Kinetic Energy

$= \Delta RKE$

$= (RKE)_f - (RKE)_0$

We know that,

Kinetic Energy, $KE = \frac{1}{2} mv^2$

Rotational Kinetic Energy, $RKE = \frac{1}{2} I \omega^2$

$\therefore \quad W = \frac{1}{2} I \omega_f^2 - \frac{1}{2} I \omega_0^2$

$= \frac{1}{2} I (\omega_f^2 - \omega_0^2)$

$= \frac{1}{2} \left(\frac{1}{2} MR^2\right) \left(\omega_f^2 - \omega_0^2\right)$

$= \frac{1}{2} \left(\frac{1}{2}(5)(0.7)^2\right) \left((60.014)^2 - (14.3)^2\right)$

$= \frac{1}{2} (1.225) (3601.68 - 204.49)$

$\boxed{W = 2080.78 J}$

Method-2:

We know that,

$W = \underbrace{F}_{\text{force}} \underbrace{d}_{\text{displacement}}$

Rotational Equivalent:

$W = \tau \cdot \theta$

$= 7 \cdot \left[\underbrace{\left(\frac{\omega_f + \omega_0}{2}\right)}_{\omega_{average}} t \right]$

$= 7 \cdot \left[\left(\frac{60.014 + 14.3}{2}\right) 8 \right]$

$= 56 \cdot \left(\frac{74.314}{2}\right)$

$= 2080.78 \ J$

2. References:

1. The Organic Chemistry Tutor

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