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# PHYS 101

## Ch. 7

## Potential Energy and Energy Conservation

# Gravitational Potential Energy

**Example 1 :**

A force F causes the 2 kg box to slide up from point A to point B. The gravitational potential energy gained by the box is:

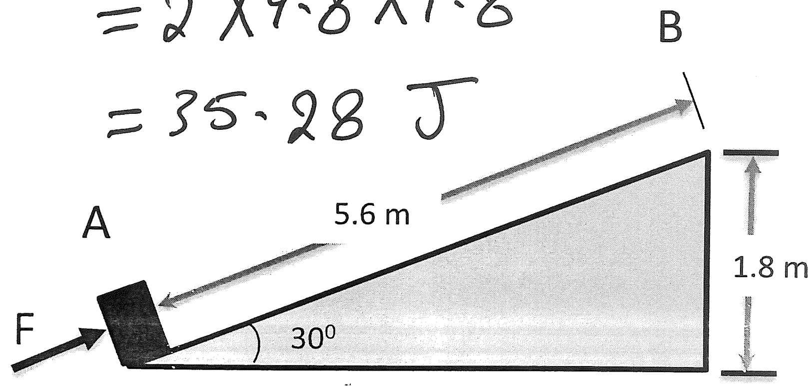
**Solution:**

(A)

$U_g = mgh$

$= 2 \times 9.8 \times 1.8$

$= 35.28\ J$




(A) 35.28 J
(B) 28.40 J
(C) 88 J
(D) 270 J

# Conservation of Mech. Energy

## Example 2:

In a sliding game at a fun fair, a child train was sliding in different heights. If the train slipped from height A 10 m till height B 7 m. The speed of the train at point B is

## Solution:

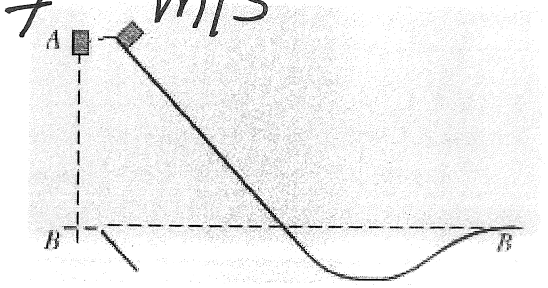
(A) 10.3 m/s
(B) 9.87 m/s
(C) 7.67 m/s
(D) 6.42 m/s

**(C)**

$v = \sqrt{2gh}$

$v = \sqrt{2 \times 9.8 \times 3}$

$v = 7.67$ m/s



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# PHYS 101

## Ch. 8

## Momentum, Impulse and Collisions

# Momentum and Impulse

## Example 1:

A force was applied on an object of mass 50 kg which changed its speed from 13 m/s to 45 m/s. The momentum for each speed is:

## Solution:

(D)

(A) 730 kg.m/s & 4450 kg.m/s
(B) 850 kg.m/s & 3250 kg.m/s
(C) 450 kg.m/s & 6550 kg.m/s
(D) 650 kg.m/s & 2250 kg.m/s

$m = 50\ kg$ $v_1 = 13\ m/s$ $v_2 = 45\ m/s$

$p = mv$

$= 50 \times 13 = 650\ kg.m/s$

---

Ⓓ ✓

$p = mv$

$= 50 \times 45 = 2250\ kg.m/s$

---

# Momentum and Impulse

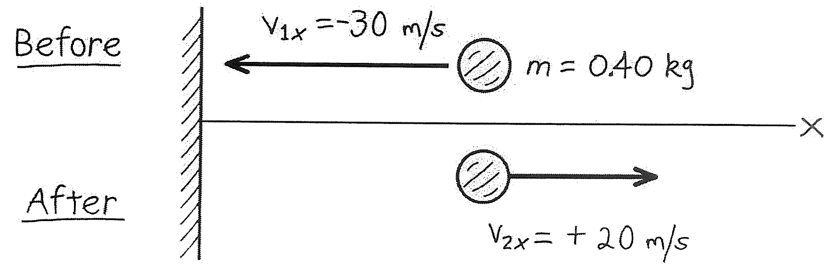
## Example 2:

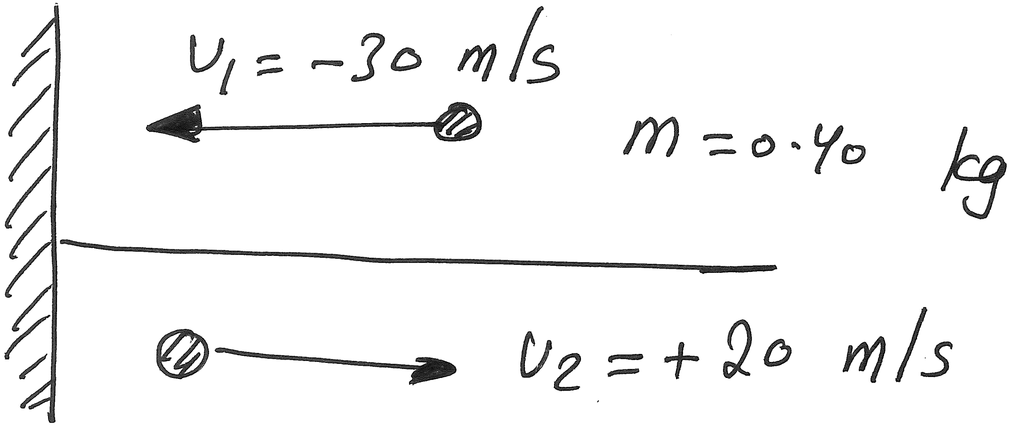
A 0.40 kg ball is initially moving to the left at 30 m/s. After hitting the wall, the ball is moving to the right at 20 m/s. The impulse of the net force on the ball during its collision with the wall is:

## Solution:

**(A)**

(A) 20 kg.m/s to the right
(B) 20 kg.m/s to the left
(C) 4.0 kg.m/s to the right
(D) 4.0 kg.m/s to the left






$$J = \Delta P = m(v_f - v_i)$$

(A)

$$J = 0.40(20+30)$$
$$= +20 \quad kg \cdot m/s \ (\text{Right})$$

# Momentum and Impulse

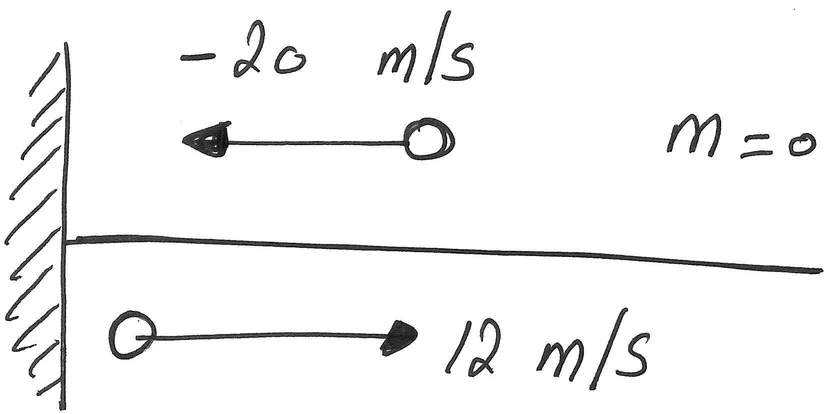
## Example 3:

During a collision with a wall, the velocity of a 0.200-kg ball changes from 20 m/s toward the wall to 12.0 m/s away from the wall. If the time when the ball was in contact with the wall is 60.0 ms, the magnitude of the average force applied to the ball is

## Solution:

**(B)**

(A) 40.0 N
(B) 107 N
(C) 16.7 N
(D) 26.7 N




$m = 0.2$ kg

$\Delta t = 60 \times 10^{-3}$ s

$$J = m(v_f - v_i)$$

$$F\Delta t = m(v_f - v_i)$$

$$F \times 60 \times 10^{-3} = 0.2(12 + 20)$$

$$F = 107 \text{ N}$$

(B)

# Momentum and Impulse

**Example 4:**

A time-varying horizontal force $F(t) = 4.5t^4 + 8.75t^2$ acts for 0.500 s on a 12.25-kg object. The impulse imparted to the object by this force is:

**Solution:**

(B)

(A) 0.023 N.s horizontally
(B) 0.617 N.s horizontally
(C) 1.862 N.s horizontally
(D) 2.371 N.s horizontally

# Conservation of Momentum

## Example 5:

On a smooth horizontal frictionless floor, an object slides into a spring which is attached to another stationary mass. Afterward, both objects are moving at the same speed. What is conserved during this interaction?

## Solution:

**(C)**

(A) momentum only
(B) momentum and kinetic energy
(C) momentum and mechanical energy
(D) momentum and potential energy

4

$F = 4.5t^4 + 8.75t^2$

$F = 4.5(0.5)^4 + 8.75(0.5)^2$ $t = 0.5\,s$

$F = 2.469\ N$

$J = F\Delta t$

$J = 2.469 \times 0.5 =$ $N.s$

# Conservation of Momentum

**Example 6:**

A baseball is thrown vertically upward and feels no air resistance. As it is rising

**Solution:**

(B)

* عند صعود الجسم لأعلى
تقل سرعته - تقل كمية الحركة
الطاقة الميكانيكية - ثابتة

(A) momentum and mechanical energy are conserved.

(B) momentum not conserved, but mechanical energy conserved.

(C) momentum and kinetic energy are conserved.

(D) kinetic energy conserved, but momentum not conserved.

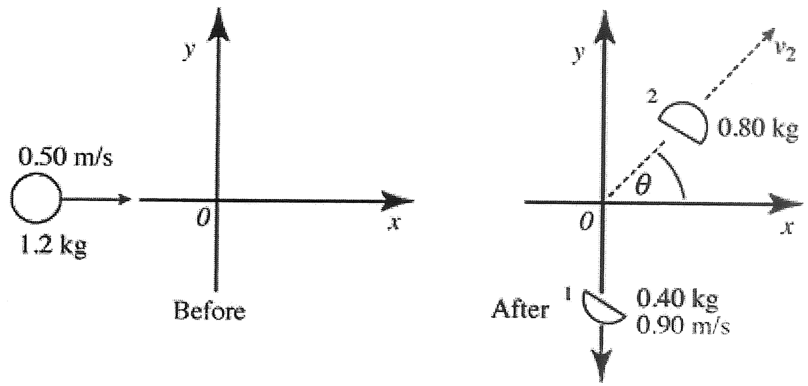
# Conservation of Momentum

## Example 7:

A 1.2-kg spring-activated toy bomb slides on a smooth surface along the x-axis with a speed of 0.50 m/s. At the origin 0, the bomb explodes into two fragments. Fragment 1 has a mass of 0.40 kg and a speed of 0.90 m/s along the negative y-axis. In the figure, the angle θ, made by the velocity vector of fragment 2 and the x-axis, is closest to

## Solution:

(A)




(A) 31°. (B) 37°.
(C) 53°. (D) 59°.

✓

$m = 1.2$ kg $\qquad v = 0.5\hat{i}$

$m_1 = 0.4$ kg $\qquad v_1 = -0.9\hat{j}$

$m_2 = 1.2 - 0.4 = 0.8$ kg

$v_2 = ?$

$$mv = m_1 v_1 + m_2 v_2$$

$$1.2 \times 0.5\hat{i} = 0.4 \times -0.9\hat{j} + 0.8 v_2$$

$$0.6\hat{i} = -0.36\hat{j} + 0.8 v_2$$

$$0.8 v_2 = +0.6\hat{i} + 0.36\hat{j}$$

$$v_2 = \frac{0.6\hat{i} + 0.36\hat{j}}{0.8} = 0.75\hat{i} + 0.45\hat{j}$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

$$\theta = \tan^{-1}\left(\frac{0.45}{0.75}\right)$$

$$\theta = 31^\circ$$

# Momentum Cons. and Collisions

## Example 8:

Two objects of the same mass move along the same line in opposite directions. The first mass is moving with speed v. The objects collide, stick together, and move with speed 0.100v in the direction of the velocity of the first mass before the collision. What was the speed of the second mass before the collision?

## Solution:

**(D)**

(A) 1.20v
(B) 10.0v
(C) 0.900v
(D) 0.800v

$m_1 = 5$ kg فرض $u_1 = U$ m/s

$m_2 = 5$ kg فرض $U_2 = ?$

السرعة المشتركة $U = 0.1U$ m/s

$$m_1 U_1 + m_2 U_2 = (m_1 + m_2) U$$

$$5 \times V + 5 U_2 = (5+5) \times 0.1 V$$

$$5V + 5V_2 = V$$

$$5U_2 = -4U$$

$$U_2 = \frac{-4}{5} U$$

$$V_2 = -0.8U \text{ m/s} \qquad |U_2| = 0.8 \text{ m/s}$$

# Momentum Cons. and Collisions

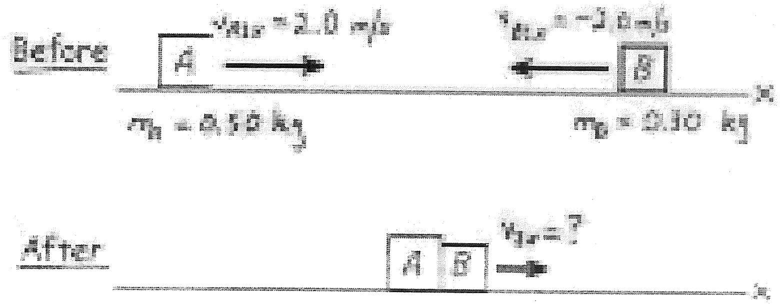
## Example 9:

Two gliders with different masses move toward each other on a frictionless air track. The gliders are equipped so that they stick together when they collide. Find the common final x-velocity?

## Solution:

**(B)**

(A) 0.2 m/s
(B) 0.5 m/s
(C) 0.9 m/s
(D) 1.2 m/s



$m_1 = 0.5$ kg | $u_1 = 2$ m/s

$m_2 = 0.3$ kg | $u_2 = -2$ m/s

حدث التصادم للجسمين معاً

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$0.5 \times 2 + 0.3 \times -2 = (0.5 + 0.3) v$$

$$V = 0.5 \text{ m/s}$$

(B)

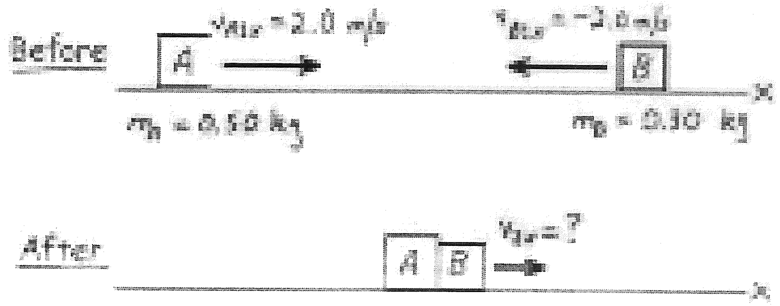
## Example 10:

Referring to Example 9, compare the initial and final kinetic energies of the system.

## Solution:

**(D)**

(A) 1/2
(B) 1/4
(C) 1/8
(D) 1/16



$m_1 = 0.5$ kg

$u_1 = 2$ m/s

$m_2 = 0.3$ kg

$u_2 = -2$ m/s

$$k_i = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$$

$$= \frac{1}{2} \times 0.5 (2)^2 + \frac{1}{2} \times 0.3 \times 2^2 = 1.6 \text{ J}$$

---

$$k_f = \frac{1}{2}(m_1 + m_2) v$$

$$= \frac{1}{2}(0.5 + 0.3) \times 0.5^2 = 0.1 \text{ J}$$

$$\frac{k_f}{k_i} = \frac{0.1}{1.6} = \frac{1}{16}$$

(d)

# Elastic Collisions

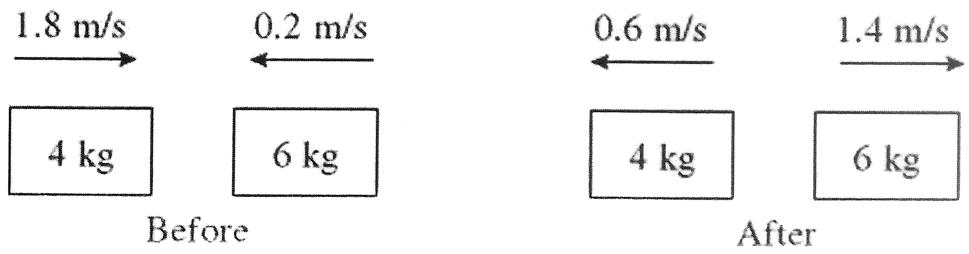
## Example 11:

In the figure, determine the character of the collision. The masses of the blocks, and the velocities before and after are given. The collision is

## Solution:

(A)

(A) perfectly elastic.
(B) partially inelastic.
(C) completely inelastic.
(D) not possible



* لم يحدث التصادم بين الجسمين

* not completely inelastic

$$K_i = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$$

$$K_i = \frac{1}{2} \times 4 \times 1.8^2 + \frac{1}{2} \times 6 \times 0.2^2 = 6.6 \text{ J}$$

---

$$K_f = \frac{1}{2} m_1 u_1'^2 + \frac{1}{2} m_2 u_2'^2$$

(a)

$$K_f = \frac{1}{2} \times 4 \times 0.6^2 + \frac{1}{2} \times 6 \times 1.4^2 = 6.6 \text{ J}$$

$K_i = K_f$ elastic collision

# Elastic Collisions

## Example 12:

A 1.0 kg object travelling at 1.0 m/s collides head on with a 2.0 kg object initially at rest. Find the velocity of each object after impact if the collision is perfectly elastic.

## Solution:

**(C)**

(A) $v_{1f} = -\ 1/2\ m/s$ and $v_{2f} = 2/3\ m/s$.
(B) $v_{1f} = -\ 1/4\ m/s$ and $v_{2f} = 2/3\ m/s$.
(C) $v_{1f} = -\ 1/3\ m/s$ and $v_{2f} = 2/3\ m/s$.
(D) $v_{1f} = -\ 1/3\ m/s$ and $v_{2f} = 2/5\ m/s$.

$m_1 = 1\ kg$ $\quad u_1 = 1\ m/s$

$m_2 = 2\ kg$ $\quad u_2 = 0$

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} \times u_1$$

$$v_2' = \frac{2m_1}{m_1 + m_2}$$

$$v_1' = \frac{1 - 2}{1+2} \times 1$$

$$= -0.33\ m/s$$

$$v_2' = \frac{2 \times 1}{1+2} \times 1 = 0.67\ m/s$$

©

# Centre of Mass

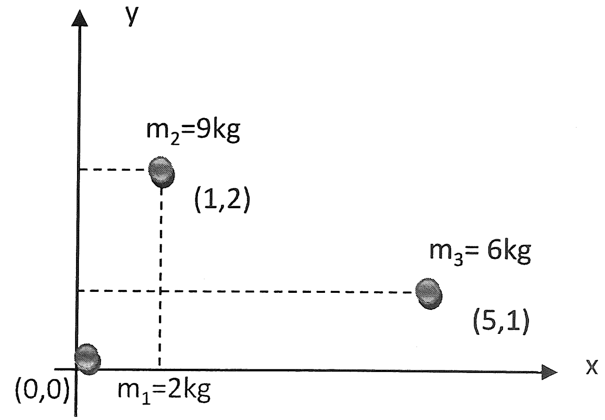
**Example 13:**

The center of mass of the objects shown in the Figure is:

**Solution:**

**(B)**

(A) (3.54, 6.54) m
(B) (2.29, 1.41) m
(C) (4.25, 3.45) m
(D) (5.65, 1.54) m



* كون الجدول التالي

| m | x | y |
|---|---|---|
| 2 | 0 | 0 |
| 6 | 5 | 1 |
| 9 | 1 | 2 |

$$x = \frac{2\times0 + 6\times5 + 9\times1}{2+6+9} = 2.29$$

$$y = \frac{2\times0 + 6\times1 + 9\times2}{2+6+9} = 1.41$$

$$= (2.29, 1.41)$$ (B)

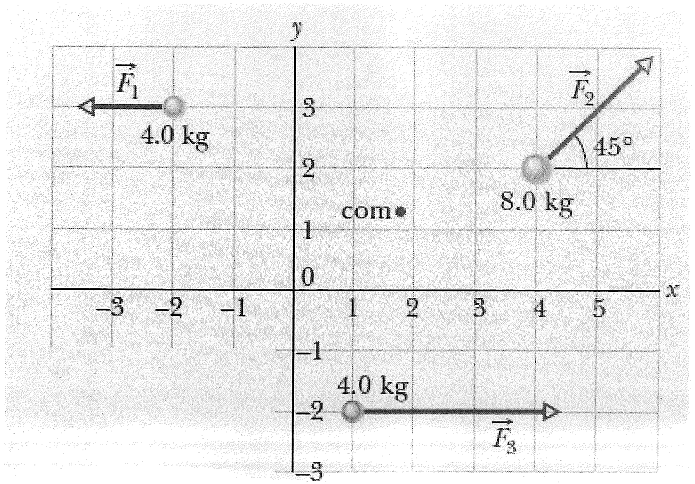
# Centre of Mass

***Example 14:***

Three particles as in Fig are initially at rest. experiences an external force. The directions are indicated, and the magnitudes are F1=6.0 N, $F_2$=12 N, and $F_3$=14 N. The acceleration of the center of mass of the system is:

***Solution:***

**(B)**




(A) 0.74 $m/s^2$
(B) 1.16 $m/s^2$
(C) 2.36 $m/s^2$
(D) 4.02 $m/s^2$

* $m_1 = 4$ kg $\quad m_2 = 8$ kg $\quad k_3 = 4$ kg

$$\Sigma m = m_1 + m_2 + m_3 \quad \Sigma m = 4 + 8 + 4 = 16 \text{ kg}$$

$F_1 = -6\hat{i} \quad F_3 = 14\hat{i}$

$F_2 = 12$ N $\quad \theta = 45°$

$$F_2 = 12\cos(45)\hat{i} + 12\sin(45)\hat{j}$$
$$= 8.49\hat{i} + 8.49\hat{j}$$

$$\Sigma F = F_1 + F_2 + F_3 = 16.49\hat{i} + 8.49\hat{j}$$

$$a_{com} = \frac{\Sigma F}{\Sigma m} = \frac{16.49\hat{i} + 8.49\hat{j}}{16}$$
$$= 1.03\hat{i} + 0.53\hat{j} \quad m/s^2$$

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# PHYS 101

## Ch. 9

## Rotation of Rigid Bodies

# Angular Velocity and Acceleration

**Example 1:**

A turbine blade of radius 5 cm rotates an angle of 60°. Find the angle of rotation in radians:

**Solution:**

**(A)**

(A) π/3 rad
(B) π/2 rad
(C) π/4 rad
(D) 60 rad

$$\theta_{rad} = \theta^{\circ} \cdot \frac{2\pi}{360}$$

$$\theta_{rad} = 60 \times \frac{2\pi}{360} = \frac{\pi}{3} \quad (a)$$

# Angular Velocity and Acceleration

## Example 2:

A turbine blade of radius 5 cm rotates an angle of 60°. Find the length of scanned arc:

## Solution:

(B)

$\theta = 60 \times \frac{2\pi}{360} = \frac{\pi}{3}$

طول القوس $S = r\theta$

$S = 5 \times \frac{\pi}{3} = \frac{5\pi}{3}$ cm

$S = \frac{5 \times 3.14}{3} = 5.23$ cm

(A) 2.74 cm
(B) 5.23 cm
(C) 3.21 cm
(D) 10.48 cm

# Angular Velocity and Acceleration

**Example 3:**

The angular position $\theta$ of a 0.18 m radius flywheel is given by $\theta = 2\ t^3$ rad. Find $\theta$ in radians at t = 2 s.

**Solution:**

(A) 4 rad
(B) 8 rad
(C) 16 rad
(D) 24 rad

(C) $\theta = 2t^3$

$t = 2$ s $\quad \theta = 2(2)^3 = 16$ rad

# Angular Velocity and Acceleration

**Example 4:**

The angular position $\theta$ of a 0.18 m radius flywheel is given by $\theta = 2t^3$ rad. Find $\theta$ in degrees at t = 2 s.

**Solution:**

(A) 920°
(B) 180°
(C) 360°
(D) 720°

(A)

$\theta = 2t^3$

$\theta = 2(2)^3 = 16$ rad

$\theta = 16 \times \frac{360}{2\pi} = 917.2^{\circ}$

(a)

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# Angular Velocity and Acceleration

## Example 5:

The angular position $\theta$ of a 0.18 m radius flywheel is given by $\theta = 2\ t^3$ rad. Find the distance that a particle on the flywheel rim moves from $t_1 = 2s$ to $t_2 = 5s$.

## Solution:

طول القوس $S = r\theta = r(\theta_2 - \theta_1)$

(B)

(A) 48 m
(B) 42 m
(C) 24 m
(D) 28 m

$t_1 = 2 \quad \theta_1 = 2(2)^3 = 16$ rad

$t_2 = 5 \quad \theta_2 = 2(5)^3 = 250$ rad

$S = 0.18(250 - 16) = 42.12$ m

B

# Angular Velocity and Acceleration

## Example 6:

The angular position $\theta$ of a 0.18 m radius flywheel is given by $\theta = 2t^3$ rad. Find the average angular velocity over that interval from $t_1 = 2s$ to $t_2 = 5s$.

## Solution:

(A) 24 rad/s
(B) 150 rad/s
(C) 78 rad/s
(D) 12 rad/s

(C) $\omega_{ave} = \frac{\theta_2 - \theta_1}{t_2 - t_1}$

$t_1 = 2$ $\quad \theta_1 = 2(2)^3 = 16$ rad

$t_2 = 5$ $\quad \theta_2 = 2 \times (5)^3 = 250$ rad

$\omega_{ave} = \frac{250 - 16}{5 - 2} = 78$ rad/s

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# Angular Velocity and Acceleration

## Example 7:

The angular position $\theta$ of a 0.18 m radius flywheel is given by $\theta = 2t^3$ rad. Find the average angular acceleration over that interval from $t_1 = 2s$ to $t_2 = 5s$.

## Solution:

(A) 24 rad/s²
(B) 60 rad/s²
(C) 42rad/s²
(D) 12 rad/s²

(C)

$$\alpha_{ave} = \frac{\omega_2 - \omega_1}{t_2 - t_1}$$

$$\theta = 2t^3$$

$$\omega = 6t^2$$

$t_1 = 2$ $\quad \omega_1 = 6(2)^2 = 24$ rad/s

$t_2 = 5$ $\quad \omega_2 = 6(5)^2 = 150$ rad/s

$$\alpha = \frac{150 - 24}{5 - 2} = 42 \text{ rad/s}^2$$

# Relating linear & angular kinematics

**Example 8:**

A turbine blade has a radius of 80 cm. At a certain instant, the blade is rotating at 10 rad/s and the angular speed is increasing at 50 rad/s$^2$. Find the linear speed.

**Solution:**

(A) 8 m/s
(B) 4 m/s
(C) 5 m/s
(D) 20 m/s

**(A)**

السرعة الخطية — $v = r\omega$

$v = 0.80 \times 10 = 8$ m/s

(A)

# Relating linear & angular kinematics

**Example 9:**

A turbine blade has a radius of 80 cm. At a certain instant, the blade is rotating at 10.0 rad/s and the angular speed is increasing at 50.0 rad/s². Find the tangential component of the acceleration.

**Solution:**

(A) 80 m/s²
(B) 40 m/s²
(C) 50 m/s²
(D) 20 m/s²

**(B)**

$$a_{tan} = r\alpha$$

$$a_{tan} = 0.80 \times 50 = 40 \text{ m/s}^2$$

# Relating linear & angular kinematics

**Example 10:**

A turbine blade has a radius of 80 cm. At a certain instant, the blade is rotating at 10.0 rad/s and the angular speed is increasing at 50.0 rad/$s^2$. Find the centripetal component of the acceleration.

**Solution:**

**(A)**

$a_{rad} = \omega^2 r$

$= (10)^2 \times 0.80$

$= 80 \ m/s^2$

(A) 80 $m/s^2$
(B) 40 $m/s^2$
(C) 50 $m/s^2$
(D) 20 $m/s^2$

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# PHYS 101

## Ch. 10

## Dynamics of Rotational Motion

# Torque

## Example 1:

A plumber stands on the end of the cheater applying 900 N weight at a point 0.80 m from the center of the fitting as shown below. The wrench handle and cheater make an angle of 19° with the horizontal. The magnitude and direction of the torque he applies about the center of the fitting is:

## Solution:

$l = 0.80 \cos(19) = 0.756\ m$

$t = lF = 0.756 \times 900 = 680\ N.m$

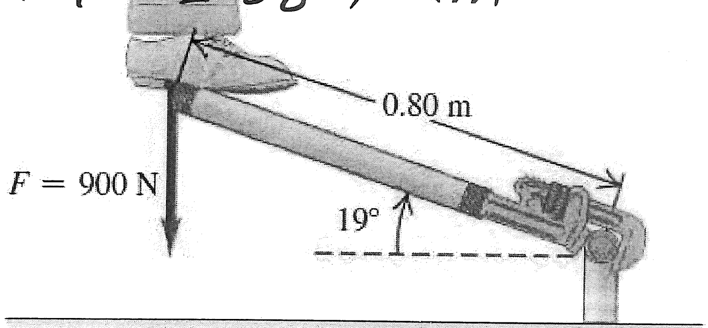
**(B)**

(A) 680 N.m, in to the page

~~(B)~~ 680 N.m, out of the page

(C) 740 N.m, in to the page

(D) 740 N.m, out of the page



## Example 2:

A particle has a mass of 0.25 kg and rotate about a point at distance 3 m with velocity given by $v = 6\ (rad/s^3)\ t^2$. The angular momentum of the particle at t = 3 s is:

## Solution:

(A) 18.4 Kg . $m^2/s$
(B) 40.5 Kg . $m^2/s$
(C) 65.7 Kg . $m^2/s$
(D) 96.8 Kg . $m^2/s$

(B)

* $m = 0.25$ kg

* $L = 3$ m

$v = 6t^2$

$t = 3$ s   $v = 6(3)^2 = 54$ m/s

$L = mvr = 0.25 \times 54 \times 3 = 40.5$ kg$\cdot m^2/s$

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# Angular Momentum

**Example 3:**

Referring to Example 2, the torque of the net force acting on the particle at t = 2 s is:

$v = 6t^2 \qquad \ell = 3\ m$

**Solution:**

(D) $a = \frac{dv}{dt} = 12t$

(A) 8 N.m
(B) 10 N.m
(C) 12 N.m
(D) 18 N.m

* $t = 2 \longrightarrow a = 12 \times 2 = 24\ m/s^2$
* $F = ma = 0.25 \times 24 = 6\ N$
* $\tau = \ell F = 3 \times 6 = 18\ N.m$