Chapter 7

The work and kinetic energy

1. A 5 Kg block moves with speed of 72 Km/h. its kinetic energy is.

(a) 1000 kg.m/s^2 **(b) 1000 kg.m^2/s^2** (c) 1200 kg.m^2/s^3 (d) 50 kg.m^3/s^2

$V = 72 km/h = 20 m/s$

$m = 5 kg$

$km/h \xrightarrow{\times(\frac{1000}{3600})} m/s$ (or $\xrightarrow{\times(5/18)}$)

$m/s \xrightarrow{\times(\frac{3600}{1000})} km/h$ (or $\xrightarrow{\times(18/5)}$)

$K = \frac{1}{2} m V^2$

$= \frac{1}{2} \times 5 (20)^2$

$= 1000 J$

2. A 5 Kg block moves with veocity of V= (6i + 8j) m/s. its kinetic energy is-----.

(a) 250 J (b) 400J (c)540J (d) 180 J

$\vec{V} = 6i + 8j$

$|\vec{V}| = \sqrt{6^2 + 8^2} = \sqrt{100} = 10$

$V = 10 m/s$

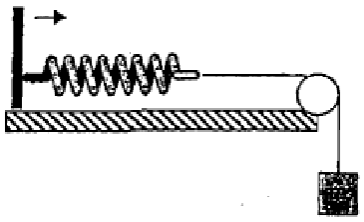
$m = 5 kg$

$K = \frac{1}{2} m V^2$

$= \frac{1}{2} \times 5 (10)^2 = 250 J$

3. As shown in the figure, if m = 5Kg and the spring force constant is 500 N/m, then the spring will stretch a distance of:

(a) 0.13 m (b) 0.147 m (c) 7.35 cm (d) 9.8 cm



$m = 5\ kg$

$F = 49\ N$

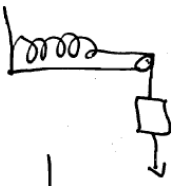
$k = 500\ N/m$

$X = ??$

$$X = \frac{F}{k}$$

$$= \frac{49}{500} = 0.098\ m$$

$$= 9.8\ cm$$



$F = mg$

$= 5 \times 9.8$

$= 49\ N$

4. Force F acts on a particle m making a displacement s. If $F = 7i + 3j - 1.5k$ (N), and $S = 2i\ 3j + 2.5\ k$ (m). The work done by the force is:

(a) 9.25 J (b) 7.25 J (c) 5.25 J (d) 1.25 J

$\vec{F} = 7i + 3j - 1.5k$

$\vec{d} = \vec{S} = 2i + 3j + 2.5k$

$w = ??$

$$w = \vec{F} \cdot \vec{d} = (14) - (9) - (3.75)$$

$$= 1.25\ J$$

5. Force F acts on a body m = 4 Kg initially moving with speed V_o = 12 m/s. The force exerts work (W = 512 J) on the body. The final speed.

(a) 22.7 m/s (b) 10 m/s (c) 5 m/s (d) 20 m/s

$m = 4\ kg$

$V_1 = 12\ m/s$

$w = 512\ J$

$V_2 = ??$

$$W = \frac{1}{2} m (V_2^2 - V_1^2)$$

$$\frac{2W}{m} = V_2^2 - V_1^2$$

$$V_2 = \sqrt{\left(\frac{2w}{m} + V_1^2\right)}$$

$$= \sqrt{\left(\frac{2 \times 512}{4} + 12^2\right)} = 20\ m/s$$

6. A force acts on a 3 Kg particle in such away that the position of the object is x = $3t - 4t^2 + t^3$ where x in meters and t in seconds. Find the work done on the object by the force from t = 0 to t = 4 s

(a) 528J (b) 10 J (c) 50 J (d) 52J

$x = 3t - 4t^2 + t^3$

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$v = 3 - 8t + 3t^2$

$t_1 = 0 \Rightarrow v_1 = 3$ m/s

$t_2 = 4 \Rightarrow v_2 = 19$ m/s

$W = \frac{1}{2} m (v_2^2 - v_1^2)$

$= \frac{1}{2} \times 3 (19^2 - 3^2)$

$= 528$ J

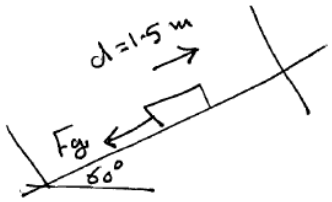
7. A 2 Kg block slides up a 60° inclined plane for 1.5 m. The work done by the force of gravity is ..... .

(a) -14.7 J **(b) 25.46 J** (c) -25.46 J (d) 14.7J

$m = 2$ kg

$F_g = mg \sin\theta$

$d = 1.5$ m



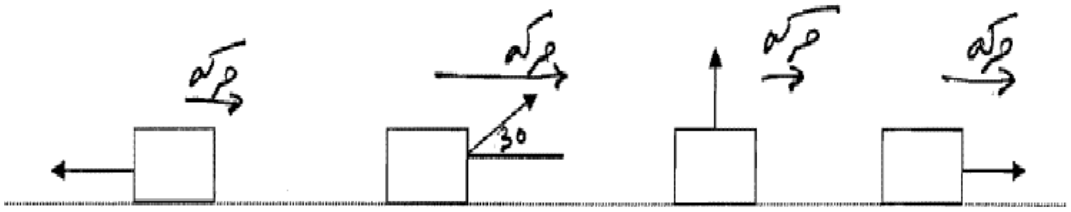
$W = F.d \cos\theta$

$= mg \sin\phi . d (\cos 180)$

$= 2 \times 9.8 \sin 60 \times 1.5 \times (-1)$

$= -25.46$ J

8. A crate moves 10m to the right on a horizontal surface by 5 N force. Find the work done by the force for each figure:



$\theta = 180$	$\theta = 30$	$\theta = 90$	$\theta = 0$
$W = F.d\cos\theta$	$W = F.d\cos\theta$	$W = F.d\cos\theta$	$W = F.d\cos\theta$
$= 5 \times 10 \cos 180$	$= 5 \times 10 \cos 30$	$= 5 \times 10 \cos 90$	$= 5 \times 10 \cos 0$
$= -50\ J$	$= 43.3\ J$	$= 0$	$= 50\ J$

9. A force F = 4 i + 3 j (N) acts on a particle ofmass 3 Kg. At a certain instant if the velocity of the particle is V = -2 i + 5 j (m / s). What is the power at this instant

(a) 7W (b)-7W (c)12W (d) -12 W

$\vec{F} = 4i + 3j$

$\vec{V} = -2i + 5j$

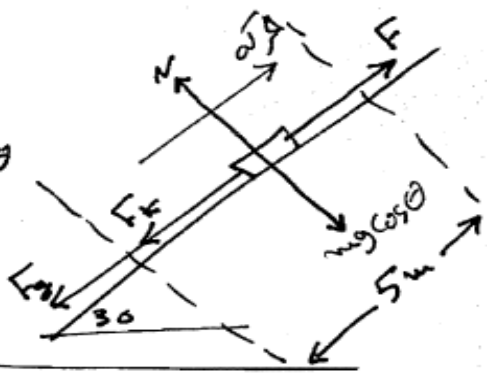
$P = \vec{F} \cdot \vec{V}$

$= -8 + 15 = 7\ w$

10. A man pushes an 80 N body a distance of 5 m upward along the rough slope (μ_k= 0.25) that makes an angle of 30° with the horizontal. The force he exerts is parallel to the slope. If the speed of the body is constant, then:

(a) The work done by the nonnal force is (b) The work done by the man is

(c) The work done by the friction is (d) The work done by the gravity is



$F = F_k + mg\sin\theta$ $(F_k = \mu N)$

$= \mu mg\cos\theta + mg\sin\theta$ $= \mu mg\cos\theta$

$= 17.3 + 40$ $= 17.3\,N$

$= 57.3\,N$

(a) $W_N = F_N \cdot d\cos\theta$ $(\theta = 90)$

$= 0$

(b) $W_m = F \cdot d\cos\theta$ $(\theta = 0)$

$= 57.3 \times 5\cos 0$ $= 286.5\,J$

(c) $W_k = F_k \cdot d\cos\theta$ $(\theta = 180)$

$= -17.3 \times 5$ $= -85.5\,J$

(d) $W_g = -(mgd\sin\phi)$ $(\theta = 180)$

$= -80 \times 5\sin 30$

$= -200\,J$

11. A horizontal force of 180 N used to pull a 50 kg box on a rough horizontal surface through a distance of 8 m. If the box moves at constant speed, find:
1-The work done by the horizontal force.

2-The work done by the frictional force.

3-The work done by the force of gravity

$F = 180\ N$

$F_k = 180\ N$

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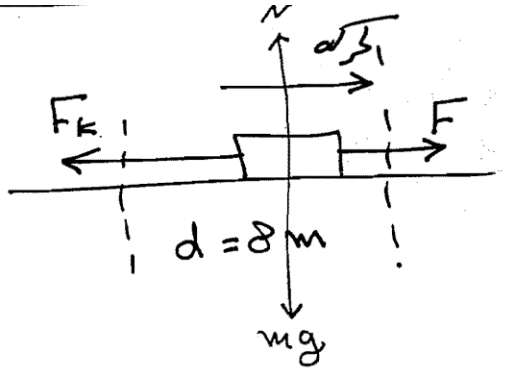
$F = F_k$



① $W = F \cdot d \cos\theta \quad (\theta = 0)$

$= 180 \times 8 \cos 0 \quad \cos 0 = 1$

$= 1440\ J$

② $W_k = -F_k \cdot d \quad (\theta = 180) \quad \cos 180 = -1$

$= -180 \times 8 = -1440\ J$

③ $W_g = F_g \cdot d \cos\theta \quad (\theta = 90) \quad \cos 90 = 0$

$= 0$

④ $W_N = F_N \cdot d \cos\theta \quad (\theta = 90) \quad \cos 90 = 0$

$= 0$

12- How much work is done to stop an 90 kg football player who is running at 8.5 m/s, horizontally?

$$w = \Delta k$$

$$w = \frac{1}{2}\, m\, v_f^2 - \frac{1}{2}\, m\, v_i^2$$

$$\rightarrow \quad v_f = 0 \qquad\qquad v_i = 8.5\ m/s^2$$

$$\therefore w = -\frac{1}{2} \times 90 \times (8.5)^2$$

$$w = -3.3 \times 10^3\ J$$

13- What is the work done by a force of 500 N that acts at an angle of 25 degrees to an object and that moves the object a displacement of 12 m?

$$\boldsymbol{w = F\,.d.cos\theta}$$

$$\boldsymbol{w = 500 \times 12 \times cos25}$$

$$\boldsymbol{w = 5.4 \times 10^3 J}$$

14-What is the kinetic energy of a 2 kg ball that travels a distance of 50 meters in 5 seconds?

$$\boldsymbol{K = \frac{1}{2}\, m\, v^2}$$

$$\boldsymbol{v = \frac{distance}{time} = \frac{50}{5} = 10\ m/s^2}$$

$$\boldsymbol{\therefore K = \frac{1}{2} \times 2 \times (10)^2}$$

$$\boldsymbol{K = 100\ J}$$

15- A ball at rest is dropped from a height of 10 m. What is its velocity before it hits the ground?

$$\boldsymbol{w = \Delta K = \frac{1}{2}\, m\, v_f^{\,2}}$$

$$\boldsymbol{v_i = 0\ because\ at\ rest} \qquad \boldsymbol{v_f} = ??$$

$$\boldsymbol{w = F.d = mgh}$$

So

$$\cancel{\boldsymbol{mgh}} = \boldsymbol{\frac{1}{2}}\, \cancel{\boldsymbol{m}}\, \boldsymbol{v_f^{\,2}}$$

$$\boldsymbol{v_f = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 10}}$$

$$\boldsymbol{v_f = 14\ m/s}$$

16-An elevator must lift 1000 kg a distance of 100 m at a velocity of 4 m/s. What is the average power the elevator exerts during this trip?

$$P = \frac{w}{t} = \frac{m\ g\ h}{t}$$

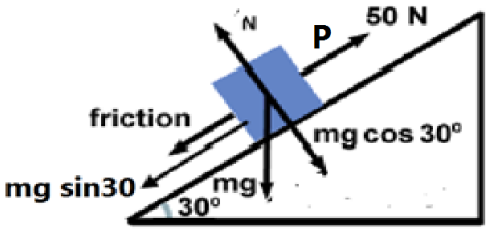
$$w = mgh = 1000 \times 9.8 \times 100 = 98 \times 10^4 J$$

$$t = \frac{d}{v} = \frac{100}{4} = 25\ sec$$

$$\therefore P = \frac{98 \times 10^4}{25}$$

$$P = 3.92 \times 10^4 watt \approx 4 \times 10^4 watt$$

17-A 5 kg block is moved up a 30 degree incline by a force of P = 50 N, parallel to the incline. The coefficient of kinetic friction between the block and the incline is 0.25. How much work is done by the 50 N force in moving the block a distance of 10 meters?



$$w = F_{net}.d$$

$$\sum F_x = p - mgsin\theta - f \ldots\ldots\ldots\ldots.1$$

$$f = \mu\, N \ldots\ldots\ldots\ldots\ldots.2$$

$$\sum F_y = 0$$

$$N - mgcos\theta = 0$$

$$N = mgcos30 = 5 \times 9.8 \times cos30 = 42.4\, N \ldots\ldots\ldots 3$$

Using 3 in 2

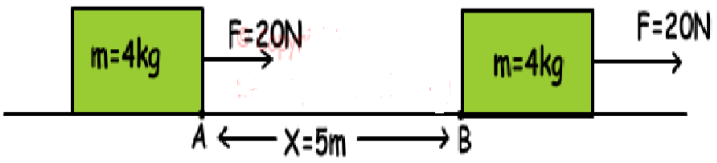
$$f = 0.25 \times 42.4 = 10.6\, N \ldots\ldots.4$$

Using 4 in 1

$$F_{net} = \sum F = 50 - 5 \times 9.8 \times sin30 - 10.6 = 14.9\, N$$

$$w = 14.9 \times 10 = 149\, J$$

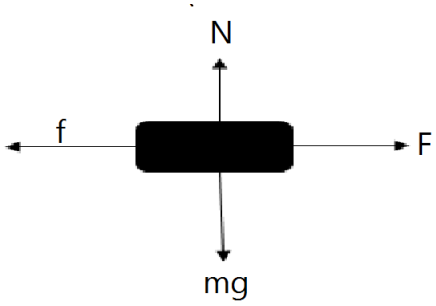
18- In the picture given above F pulls a box having 4kg mass from point A to B. If the friction constant between surface and box is 0,3; find the work done by F, work done by friction force and work done by resultant force.



$$w = F_{net}.d$$

$$\sum F_x = F - f$$

$$f = \mu N = \mu \times mg = 0.3 \times 4 \times 9.8 = 11.76\ N$$



$$\sum F = 20 - 11.76 = 8.24N$$

$$\therefore w = 8.24 \times 5 = 41.2\ J$$

19- A machine does 2500 J of work in 1 min. What is the power developed by the machine?

A. 21 W **B. 42 W** C. 150 W D. 2500 W E. 150000 W

$$p = \frac{w}{t} = \frac{2500}{1 \times 60} = 41.6 \approx 42\ watt$$

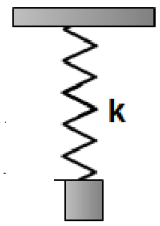
20 - A car travels with a constant speed of 15 m/s. The car's engine produces a 4000 N pushing force in order to keep the speed constant. How much power is developed by the engine?

A. 60 W B. 600 W C. 6000 W **D. 60000 W**

$$p = F\ v = 4000 \times 15 = 60000\ watt$$

21- A 4 kg block is attached to a vertical spring with a spring constant 800 N/m. The spring stretches 5 cm down. How much elastic potential energy is stored in the system?

A. 1.0 J B. 0.5 J C. 1.5 J D. 2.0 J



$$w = \frac{1}{2}kx^2$$

$$w = \frac{1}{2} \times 800 \times (5 \times 10^{-2})^2 = 1\,J$$

22- What happens to the kinetic energy of a moving object if the net work done is positive?

A. **The kinetic energy increases**
B. The kinetic energy decreases
C. The kinetic energy remains the same
D. The kinetic energy is zero

23- A bus travels with a constant force of 5000 N and work done by bus is 2500 J, distance travelled by bus is

A. 2 m
B. **0.5 m**
C. 7500 m
D. 2500 m

$$W = F\,.d \;\rightarrow\; d = \frac{W}{F} = \frac{2500}{5000} = 0.5\,m$$

24- When force is applied on an object but object does not move, it means that

A. no power is used
B. no work is done
C. work is done
D. power is used

25 – The work done on an object does not depended upon the :

A. the displacement
B. the force applied
C. the angle between the force and the displacement
D. <u>the initial velocity of the object</u>

26- When angle between force and displacement is 90° then work done is

A. <u>0 J</u>
B. 1 J
C. 10 J
D. 50 J

27 - Rate at which a body does work is called

A. Energy
B. <u>Power</u>
C. Change of kinetic energy
D. none of above
E.

28- Find the work done by a 45 N force in pulling the luggage carrier at an angle $\theta = 50^{o}$ for a distance $s = 75$m.

Solution

$$W = (F\cos\theta)\, s = 45 \cos 50^{\circ} \times 75 = 2170\text{J}$$

29- A force $F = (6i - 2j)$ N acts on a particle that undergoes a displacement $s = (3i + j)$ m. Find (a) the work done by the force on the particle and (b) the angle between F and s.

(a) $W = \vec{F} . \vec{s} = (6i - 2j).(3i + j) = (6)(3) + (-2)(1) = 18 - 2 = 16\text{J}$

(b) $F = \sqrt{F_x^2 + F_y^2} = \sqrt{6^2 + (-2)^2} = 6.32\text{N}$

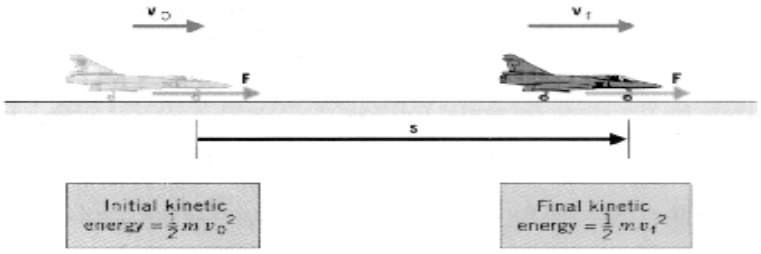
$s = \sqrt{s_x^2 + s_y^2} = \sqrt{3^2 + 1^2} = 3.16\text{m}$

$W = F\, s \cos\theta$

$\cos\theta = \dfrac{W}{Fs} = \dfrac{16}{6.32 \times 3.16} = 0.8012$

$\theta = \cos^{-1}(0.8012) = 36.8^\circ$

30- A fighter-jet of mass 5×10^4kg is travelling at a speed of $v_i=1.1\times10^4$m/s as showing in Figure The engine exerts a constant force of 4×10^5N for a displacement of 2.5×10^6m. Determine the final speed of the jet.



The work done on the engine is

$$W = (F\cos\theta)\, s = 4\times10^5 \cos 0^\circ \times 2.5\times10^6 = 1\times10^{12}\text{J}$$

The work is positive, because the force and displacement are in the same direction as shown in Figure since $W = K\text{f} - K\text{i}$ the final kinetic energy of the fighter jet is

$$K_f = W + K_i$$

$$= (1\times10^{12}\text{J}) + ½\ (5\times10^{4}\text{kg})\ (1\times10^{4}\text{m/s})^2 = 4.031\times10^{12}\text{J}$$

The final kinetic energy is $K_f = ½\ mv_f^2$, so the final speed is

$$v_f = \sqrt{\frac{2K_f}{m}} = \sqrt{\frac{2(4.03\times10^{12})}{5\times10^{4}}} = 1.27\times10^{4}\ \text{m/s}$$

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31- Choose the correct answer

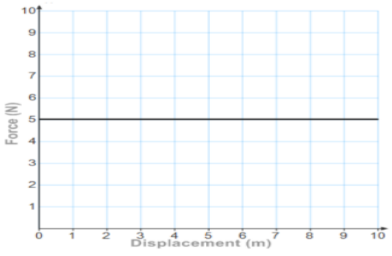
1. When angle between force and displacement is 90° then work done is

A. 0 J
B. 1 J
C. 10 J
D. 50 J

2. A pendulum bob moves at a speed of 2 ms^{-1} and mass of 0.5 kg, its E_k would be

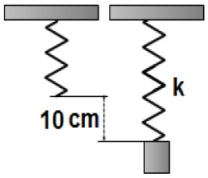
A. 1 J
B. 0.25 J
C. 0.5 J
D. 2 J

3. The force as a function of displacement of a moving object is presented by the graph. How much work is done when the object moves from 0 m to 8 m?



A. 40 J **B. 2** **C. 0 J** **D. 10J**

4 A heavy block is suspended from a vertical spring. The elastic potential energy is stored in the spring is 2 J. What is the spring constant if the elongation of the spring is 10 cm?



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