Work, Energy, Power and Collision

SET Self Evaluation Test -6

1. How much work does a pulling force of 40 *N* do on the 20 *kg* box in pulling it 8 *m* across the floor at a constant speed. The pulling force is directed at 60° above the horizontal

(a) 160 *J* (b) 277 *J*
(c) 784 *J* (d) None of the above

2. A horizontal force of 5 *N* is required to maintain a velocity of 2 *m/s* for a block of 10 *kg* mass sliding over a rough surface. The work done by this force in one minute is

(a) 600 *J* (b) 60 *J*
(c) 6 *J* (d) 6000 *J*

3. Work done in time *t* on a body of mass *m* which is accelerated from rest to a speed *v* in time t_1 as a function of time *t* is given by

(a) $\frac{1}{2}m\frac{v}{t_1}t^2$ (b) $m\frac{v}{t_1}t^2$
(c) $\frac{1}{2}\left(\frac{mv}{t_1}\right)^2 t^2$ (d) $\frac{1}{2}m\frac{v^2}{t_1^2}t^2$

4. What is the shape of the graph between the speed and kinetic energy of a body

(a) Straight line (b) Hyperbola
(c) Parabola (d) Exponential

5. When a body moves with some friction on a surface

(a) It loses kinetic energy but momentum is constant
(b) It loses kinetic energy but gains potential energy
(c) Kinetic energy and momentum both decrease
(d) Mechanical energy is conserved

6. A bullet of mass *m* moving with velocity *v* strikes a suspended wooden block of mass *M*. If the block rises to a height *h*, the initial velocity of the block will be

(a) $\sqrt{2gh}$ (b) $\frac{M+m}{m}\sqrt{2gh}$
(c) $\frac{m}{M+m}2gh$ (d) $\frac{M+m}{M}\sqrt{2gh}$

7. There will be decrease in potential energy of the system, if work is done upon the system by

(a) Any conservative or non-conservative force
(b) A non-conservative force
(c) A conservative force
(d) None of the above

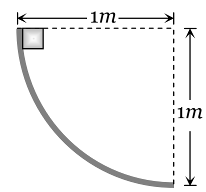
8. The slope of kinetic energy displacement curve of a particle in motion is

(a) Equal to the acceleration of the particle
(b) Inversely proportional to the acceleration
(c) Directly proportional to the acceleration
(d) None of the above

9. The energy required to accelerate a car from 10 m/s to 20 *m/s* is how many times the energy required to accelerate the car from rest to 10 *m/s*

(a) Equal (b) 4 times
(c) 2 times (d) 3 times

10. A body of mass 2 *kg* slides down a curved track which is quadrant of a circle of radius 1 *metre*. All the surfaces are frictionless. If the body starts from rest, its speed at the bottom of the track is



(a) 4.43 *m/sec*
(b) 2 *m/sec*
(c) 0.5 *m/sec*
(d) 19.6 *m/sec*

11. The kinetic energy of a body decreases by 36%. The decrease in its momentum is

(a) 36% (b) 20%
(c) 8% (d) 6%

12. A bomb of mass 3*m kg* explodes into two pieces of mass *m kg* and 2*m kg*. If the velocity of *m kg* mass is 16 *m/s*, the total kinetic energy released in the explosion is

(a) 192 *mJ* (b) 96 *mJ*
(c) 384 *mJ* (d) 768 *mJ*

13. Which one of the following statement does not hold good when two balls of masses m_1 and m_2 undergo elastic collision

(a) When $m_1 << m_2$ and m_2 at rest, there will be maximum transfer of momentum
(b) When $m_1 >> m_2$ and m_2 at rest, after collision the ball of mass m_2 moves with four times the velocity of m_1
(c) When $m_1 = m_2$ and m_2 at rest, there will be maximum transfer of K.E.
(d) When collision is oblique and m_2 at rest with $m_1 = m_2$, after collision the balls move in opposite directions

14. A neutron travelling with a velocity *v* and K.E. *E* collides perfectly elastically head on with the nucleus of an atom of mass number *A* at rest. The fraction of total energy retained by neutron is

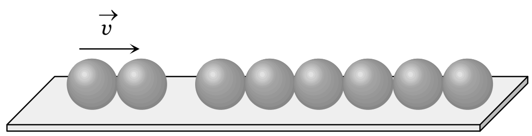
(a) $\left(\frac{A-1}{A+1}\right)^2$ (b) $\left(\frac{A+1}{A-1}\right)^2$
(c) $\left(\frac{A-1}{A}\right)^2$ (d) $\left(\frac{A+1}{A}\right)^2$

15. A body of mass m_1 moving with uniform velocity of 40 m/s collides with another mass m_2 at rest and then the two together begin to move with uniform velocity of 30 m/s. The ratio of their masses $\frac{m_1}{m_2}$ is

(a) 0.75 (b) 1.33

(c) 3.0 (d) 4.0

16. Six identical balls are lined in a straight groove made on a horizontal frictionless surface as shown. Two similar balls each moving with a velocity v collide elastically with the row of 6 balls from left. What will happen



(a) One ball from the right rolls out with a speed $2v$ and the remaining balls will remain at rest

(b) Two balls from the right roll out with speed v each and the remaining balls will remain stationary

(c) All the six balls in the row will roll out with speed $v/6$ each and the two colliding balls will come to rest

(d) The colliding balls will come to rest and no ball rolls out from right

17. A wooden block of mass M rests on a horizontal surface. A bullet of mass m moving in the horizontal direction strikes and gets embedded in it. The combined system covers a distance x on the surface. If the coefficient of friction between wood and the surface is μ, the speed of the bullet at the time of striking the block is (where m is mass of the bullet)

(a) $\sqrt{\frac{2Mg}{\mu m}}$ (b) $\sqrt{\frac{2\mu mg}{Mx}}$

(c) $\sqrt{2\mu gx}\left(\frac{M+m}{m}\right)$ (d) $\sqrt{\frac{2\mu mx}{M+m}}$

18. A ball moving with speed v hits another identical ball at rest. The two balls stick together after collision. If specific heat of the material of the balls is S, the temperature rise resulting from the collision is

(a) $\frac{v^2}{8S}$ (b) $\frac{v^2}{4S}$

(c) $\frac{v^2}{2S}$ (d) $\frac{v^2}{S}$

19. A bag of sand of mass M is suspended by a string. A bullet of mass m is fired at it with velocity v and gets embedded into it. The loss of kinetic energy in this process is

(a) $\frac{1}{2}mv^2$ (b) $\frac{1}{2}mv^2 \times \frac{1}{M+m}$

(c) $\frac{1}{2}mv^2 \times \frac{M}{m}$ (d) $\frac{1}{2}mv^2\left(\frac{M}{M+m}\right)$

Answers and Solutions

(SET -6)

1. (a) $W = \vec{F}.\vec{s} = 40 \times 8 \times \cos 60° = 160\ J$

2. (a) $W = F \times s = F \times v \times t = 5 \times 2 \times 60 = 600\ J$

3. (d) Work done $= F \times s = ma \times \frac{1}{2}at^2$ $\left[\text{from } s = ut + \frac{1}{2}at^2\right]$

$\therefore W = \frac{1}{2}ma^2t^2 = \frac{1}{2}m\left(\frac{v}{t_1}\right)^2 t^2$ $\left[\text{As } a = \frac{v}{t_1}\right]$

4. (c) Kinetic energy $k = \frac{1}{2}mv^2 \Rightarrow k \propto v^2$

It means the graph between the speed and kinetic energy will parabola

5. (c) Friction is a non-conservative external force to the system, it decreases momentum and kinetic energy both.

6. (a) Initial K.E. of block when bullet strikes to it

$= \frac{1}{2}(m+M)V^2$

Due to this K.E. block will rise to a height h.

Its potential energy = $(m+M)gh$.

By the law of conservation of energy

$\frac{1}{2}(m+M)V^2 = (m+M)gh$ $\therefore V = \sqrt{2gh}$

7. (c)

8. (c) $E = \frac{1}{2}mv^2$. Differentiating *w.r.t. x*, we get

$$\frac{dE}{dx} = \frac{1}{2}m \times 2v\frac{dv}{dx} = mv \times \frac{dv}{dt} \times \frac{dt}{dx} = mv \times \frac{a}{v} = ma$$

9. (d) Kinetic energy for first condition

$= \frac{1}{2}m\left(v_2^2 - v_1^2\right) = \frac{1}{2}m\left(20^2 - 10^2\right) = 150\ mJ$

K.E. for second condition $= \frac{1}{2}m\left(10^2 - 0^2\right) = 50mJ$

$\therefore \frac{(K.E.)I}{(K.E.)II} = \frac{150m}{50m} = 3$

10. (a) By conservation of energy, $mgh = \frac{1}{2}mv^2$

$\Rightarrow v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 1} = \sqrt{19.6} = 4.43\ m/s$

11. (b) $P = \sqrt{2mE}$ $\therefore P \propto \sqrt{E}$

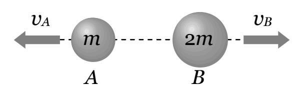
In given problem K.E. becomes 64% of the original value.

$\frac{P_2}{P_1} = \sqrt{\frac{E_2}{E_1}} = \sqrt{\frac{64\,E}{100\,E}} = 0.8 \Rightarrow P_2 = 0.8\ P$

$\therefore P_2 = 80\%$ of the original value.

i.e. decrease in momentum is 20%.

12. (a)



By the conservation of momentum, $m_Av_A = m_Bv_B$

$\Rightarrow m \times 16 = 2m \times v_B \Rightarrow v_B = 8\ m/s$

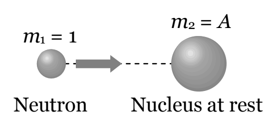
Kinetic energy of system $= \frac{1}{2}m_Av_A^2 + \frac{1}{2}m_Bv_B^2$

$= \frac{1}{2} \times m \times (16)^2 + \frac{1}{2} \times (2m) \times 8^2 = 192\ m\,J$

13. (b,d) When $m_1 > m_2$ and m_2 at rest, after collision the ball of mass m_2 moves with double the velocity of u_1. So option (b) is incorrect.

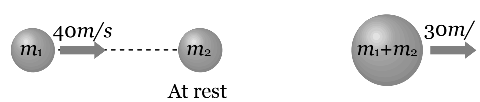
When collision is oblique and m_2 at rest with $m_1 = m_2$, after collision the ball moves in perpendicular direction. So option (d) is also incorrect.

14. (a)



$$\left(\frac{\Delta k}{k}\right)_{\text{retained}} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 = \left(\frac{1-A}{1+A}\right)^2$$

15. (c)



Initial momentum of the system = $m_1 \times 40 + m_2 \times 0$

Final momentum of the system = $(m_1 + m_2) \times 30$

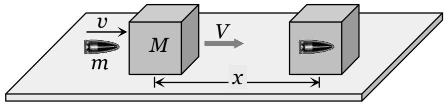
By the law of conservation of momentum

$m_1 \times 40 + m_2 \times 0 = (m_1 + m_2) \times 30$

$\Rightarrow 40m_1 = 30m_1 + 30m_2 \Rightarrow 10m_1 = 30m_2 = \frac{m_1}{m_2} = 3$

16. (b) Momentum and kinetic energy is conserved only in this case.

17. (c)



Let speed of the bullet = v

Speed of the system after the collision = V

By conservation of momentum $mv = (m+M)V$

$$\Rightarrow V = \frac{mv}{M+m}$$

So the initial K.E. acquired by the system

$$= \frac{1}{2}(M+m)V^2 = \frac{1}{2}(m+M)\left(\frac{mv}{M+m}\right)^2 = \frac{1}{2}\frac{m^2v^2}{(m+M)}$$

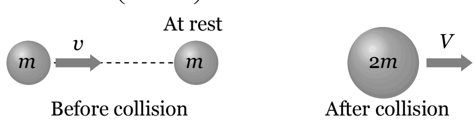
This kinetic energy goes against friction work done by friction = $\mu R \times x = \mu(m+M)g \times x$

By the law of conservation of energy

$$\frac{1}{2}\frac{m^2v^2}{(m+M)} = \mu(m+M)g \times x \Rightarrow v^2 = 2\mu gx\left(\frac{m+M}{m}\right)^2$$

$$\therefore\ v = \sqrt{2\mu gx}\left(\frac{M+m}{m}\right)$$

18. (a)



Initial momentum = mv

Final momentum = $2mV$

By the conservation of momentum, $mv = 2mV$

$$\Rightarrow V = \frac{v}{2}$$

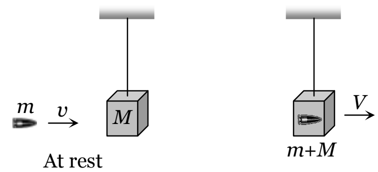
K.E. of the system after the collision = $\frac{1}{2}(2m)\left(\frac{v}{2}\right)^2$

$\therefore$ loss in K.E. $= \frac{1}{2}mv^2 - \frac{1}{4}mv^2 = \frac{1}{4}mv^2$

This loss in K.E. will increase the temperature

$$\therefore\ 2m \times s \times \Delta t = \frac{1}{4}mv^2 \Rightarrow \Delta t = \frac{v^2}{8s}$$

19. (d)



Initial kinetic energy of bullet = $\frac{1}{2}mv^2$

After inelastic collision system moves with velocity V

By the conservation of momentum

$$mv + 0 = (m+M)V \Rightarrow V = \frac{mv}{m+M}$$

Kinetic energy of system = $\frac{1}{2}(m+M)V^2$

$$= \frac{1}{2}(m+M)\left(\frac{mv}{m+M}\right)^2$$

Loss of kinetic energy = $\frac{1}{2}mv^2 - \frac{1}{2}(m+M)\left(\frac{mv}{m+M}\right)^2$

$$= \frac{1}{2}mv^2\left(\frac{M}{m+M}\right)$$

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