PHYSICS

Work, Energy and Power

Speed TEST 5

Chapter-wise

No. of Questions	Maximum Marks	Time
30	120	1 Hour

GENERAL INSTRUCTIONS

- This test contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solutions provided at the end of this book.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

1. A spring of spring constant 5×10^3 N/m is stretched initially by 5cm from the unstretched position. Then the work required to stretch it further by another 5 cm is

(a) 12.50 Nm (b) 18.75 Nm
(c) 25.00 Nm (d) 6.25 Nm

2. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion ?

(a) 0.1 m/s^2 (b) 0.15 m/s^2
(c) 0.18 m/s^2 (d) 0.2 m/s^2

3. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to

(a) $t^{3/4}$ (b) $t^{3/2}$ (c) $t^{1/4}$ (d) $t^{1/2}$

4. A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0. It collides with the ground and loses 50% of its energy in collision and rebounds to the same height. The initial velocity v_0 is : (Take g = 10 ms^{-2})

(a) 20 ms^{-1} (b) 28 ms^{-1}
(c) 10 ms^{-1} (d) 14 ms^{-1}

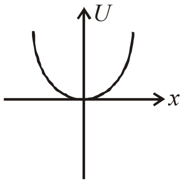
5. When a rubber-band is stretched by a distance x, it exerts restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is:

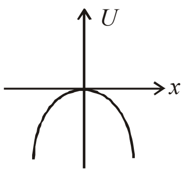
(a) $aL^2 + bL^3$ (b) $\frac{1}{2}\left(aL^2 + bL^3\right)$

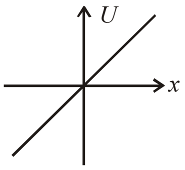
(c) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (d) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

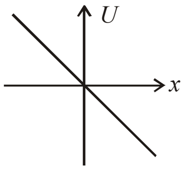
RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

6. A particle is acted by a force $F = kx$, where k is a +ve constant. Its potential energy at $x = 0$ is zero. Which curve correctly represents the variation of potential energy of the block with respect to x

(a) 

(b) 

(c) 

(d) 

7. A particle of mass m is driven by a machine that delivers a constant power of k watts. If the particle starts from rest the force on the particle at time t is

(a) $\sqrt{mk}\ t^{-1/2}$ (b) $\sqrt{2mk}\ t^{-1/2}$

(c) $\frac{1}{2}\sqrt{mk}\ t^{-1/2}$ (d) $\sqrt{\frac{mk}{2}}t^{-1/2}$

8. A moving body with a mass m_1 and velocity u strikes a stationary body of mass m_2. The masses m_1 and m_2 should be in the ratio m_1/m_2 so as to decrease the velocity of the first body to 2u/3 and giving a velocity of v to m_2 assuming a perfectly elastic impact. Then the ratio m_1/m_2 is

(a) 5 (b) 1/5 (c) 1/25 (d) 25

9. Two similar springs P and Q have spring constants K_P and K_Q, such that $K_P > K_Q$. They are stretched, first by the same amount (case a,) then by the same force (case b). The work done by the springs W_P and W_Q are related as, in case (a) and case (b), respectively

(a) $W_P = W_Q$; $W_P = W_Q$

(b) $W_P > W_Q$; $W_Q > W_P$

(c) $W_P < W_Q$; $W_Q < W_P$

(d) $W_P = W_Q$; $W_P > W_Q$

10. A body is allowed to fall freely under gravity from a height of 10m. If it looses 25% of its energy due to impact with the ground, then the maximum height it rises after one impact is

(a) 2.5m (b) 5.0m (c) 7.5m (d) 8.2m

11. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of energy. How much power is generated by the turbine?(g = 10 m/s^2)

(a) 8.1 kW (b) 10.2 kW

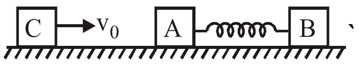
(c) 12.3 kW (d) 7.0 kW

12. A glass marble dropped from a certain height above the horizontal surface reaches the surface in time t and then continues to bounce up and down. The time in which the marble finally comes to rest is

(a) $e^n t$ (b) $e^2 t$

(c) $t\left[\frac{1+e}{1-e}\right]$ (d) $t\left[\frac{1-e}{1+e}\right]$

13. A block C of mass m is moving with velocity v_0 and collides elastically with block A of mass m and connected to another block B of mass 2m through spring constant k. What is k if x_0 is compression of spring when velocity of A and B is same?

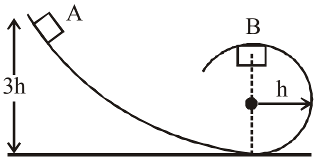


(a) $\frac{mv_0^2}{x_0^2}$ (b) $\frac{mv_0^2}{2x_0^2}$

(c) $\frac{3}{2}\frac{mv_0^2}{x_0^2}$ (d) $\frac{2}{3}\frac{mv_0^2}{x_0^2}$

RESPONSE GRID					
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ		

14. In the figure shown, a particle of mass m is released from the position A on a smooth track. When the particle reaches at B, then normal reaction on it by the track is



(a) mg (b) 2mg (c) $\frac{2}{3}$mg (d) $\frac{m^2g}{h}$

15. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F}=(2t\hat{i}+3t^2\hat{j})$ N, where $\hat{i}$ and $\hat{j}$ are unit vectors alogn x and y axis. What power will be developed by the force at the time t?

(a) $(2t^2 + 3t^3)$W (b) $(2t^2 + 4t^4)$W
(c) $(2t^3 + 3t^4)$ W (d) $(2t^3 + 3t^5)$W

16. A bullet of mass 20 g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is the velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision?

(a) 200 m/s (b) 150 m/s (c) 400 m/s (d) 300 m/s

17. A body of mass m kg is ascending on a smooth inclined plane of inclination θ $\left(\sin\theta = \frac{1}{x}\right)$ with constant acceleration of a m/s^2. The final velocity of the body is v m/s. The work done by the body during this motion is (Initial velocity of the body = 0)

(a) $\frac{1}{2}mv^2(g + xa)$ (b) $\frac{mv^2}{2}\left(\frac{g}{2}+a\right)$
(c) $\frac{2mv^2x}{a}(a + gx)$ (d) $\frac{mv^2}{2ax}(g + xa)$

18. The potential energy of a 1 kg particle free to move along the x-axis is given by $V(x) = \left(\frac{x^4}{4} - \frac{x^2}{2}\right)$ J.

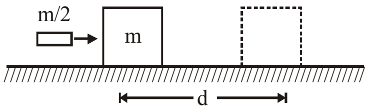
The total mechanical energy of the particle is 2 J. Then, the maximum speed (in m/s) is

(a) $\frac{3}{\sqrt{2}}$ (b) $\sqrt{2}$
(c) $\frac{1}{\sqrt{2}}$ (d) 2

19. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0. The instantaneous velocity of this car is proportional to :

(a) t^2P_0 (b) $t^{1/2}$
(c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$

20. A block of mass m rests on a rough horizontal surface (Coefficient of friction is μ). When a bullet of mass m/2 strikes horizontally, and get embedded in it, the block moves a distance d before coming to rest. The initial velocity of the bullet is $k\sqrt{2\mu gd}$, then the value of k is



(a) 2 (b) 3
(c) 4 (d) 5

21. A force acts on a 30 gm particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 seconds is

(a) 576mJ (b) 450mJ
(c) 490mJ (d) 530mJ

22. A steel ball of mass 5g is thrown downward with velocity 10 m/s from height 19.5 m. It penetrates sand by 50 cm. The change in mechanical energy will be ($g = 10$ m/s^2)

(a) 1J (b) 1.25 J
(c) 1.5 J (d) 1.75 J

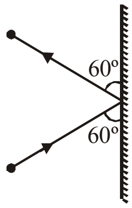
RESPONSE GRID					
	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	

23. A 10 H.P. motor pumps out water from a well of depth 20 m and fills a water tank of volume 22380 litres at a height of 10 m from the ground. The running time of the motor to fill the empty water tank is ($g = 10ms^{-2}$)

(a) 5 minutes (b) 10 minutes

(c) 15 minutes (d) 20 minutes

24. A 3 kg ball strikes a heavy rigid wall with a speed of 10 m/s at an angle of 60º. It gets reflected with the same speed and angle as shown here. If the ball is in contact with the wall for 0.20s, what is the average force exerted on the ball by the wall?



(a) 150N (b) 300N (c) $150\sqrt{3}$N (d) zero

25. A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by

(a) 8.5 cm (b) 5.5 cm (c) 2.5 cm (d) 11.0 cm

26. A stone is tied to a string of length ℓ and is whirled in a vertical circle with the other end of the string as the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of the change in velocity as it reaches a position where the string is horizontal (g being acceleration due to gravity) is

(a) $\sqrt{2g\ell}$ (b) $\sqrt{2(u^2 - g\ell)}$

(c) $\sqrt{u^2 - g\ell}$ (d) $u - \sqrt{u^2 - 2g\ell}$

27. An engine pumps water through a hose pipe. Water passes through the pipe and leaves it with a velocity of 2 m/s. The mass per unit length of water in the pipe is 100 kg/m. What is the power of the engine?

(a) 400 W (b) 200 W

(c) 100 W (d) 800 W

28. A body of mass 50kg is projected vertically upwards with velocity of 100 m/sec. After 5 seconds this body breaks into two pieces of 20 kg and 30 kg. If 20 kg piece travels upwards with 150 m/sec, then the velocity of other block will be

(a) 15 m/sec downwards (b) 15 m/sec upwards

(c) 51 m/sec downwards (d) 51 m/sec upwards

29. The K.E. acquired by a mass m in travelling a certain distance d, starting form rest, under the action of a constant force is directly proportional to

(a) m (b) $\sqrt{m}$

(c) $\frac{1}{\sqrt{m}}$ (d) independent of m

30. A vertical spring with force constant k is fixed on a table. A ball of mass m at a height h above the free upper end of the spring falls vertically on the spring so that the spring is compressed by a distance d. The net work done in the process is

(a) $mg(h+d) - \frac{1}{2}kd^2$ (b) $mg(h-d) - \frac{1}{2}kd^2$

(c) $mg(h-d) + \frac{1}{2}kd^2$ (d) $mg(h+d) + \frac{1}{2}kd^2$

RESPONSE GRID					
	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ
	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ		

PHYSICS CHAPTERWISE SPEED TEST-5			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

HINTS & SOLUTIONS (PHYSICS – Chapter-wise Tests)

Speed Test-5

1. **(b)** $k = 5 \times 10^3$ N/m

$$W = \frac{1}{2}k\left(x_2^2 - x_1^2\right) = \frac{1}{2} \times 5 \times 10^3\left[(0.1)^2 - (0.05)^2\right]$$

$$= \frac{5000}{2} \times 0.15 \times 0.05 = 18.75\ \text{Nm}$$

2. **(a)** Given: Mass of particle, $M = 10\text{g} = \frac{10}{1000}$ kg

radius of circle R = 6.4 cm

Kinetic energy E of particle = 8×10^{-4}J

acceleration a_t = ?

$$\frac{1}{2}mv^2 = E$$

$$\Rightarrow \quad \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8 \times 10^{-4}$$

$\Rightarrow \quad v^2 = 16 \times 10^{-2}$

$\Rightarrow \quad v = 4 \times 10^{-1} = 0.4$ m/s

Now, using

$v^2 = u^2 + 2a_t s \qquad (s = 4\pi R)$

$$(0.4)^2 = 0^2 + 2a_t\left(4 \times \frac{22}{7} \times \frac{6.4}{100}\right)$$

$$\Rightarrow \quad a_t = (0.4)^2 \times \frac{7 \times 100}{8 \times 22 \times 6.4} = 0.1\ \text{m/s}^2$$

3. **(b)** We know that $F \times v$ = Power

$\therefore\ F \times v = c$ where c = constant

$$m\frac{dv}{dt} \times v = c \qquad \left(\because F = ma = \frac{mdv}{dt}\right)$$

$$m\int_0^v vdv = c\int_0^t dt \qquad \Rightarrow \frac{1}{2}mv^2 = ct$$

$$v = \sqrt{\frac{2c}{m}} \times t^{1/2}$$

$$\frac{dx}{dt} = \sqrt{\frac{2c}{m}} \times t^{1/2} \qquad \text{where } v = \frac{dx}{dt}$$

$$\int_0^x dx = \sqrt{\frac{2c}{m}} \times \int_0^t t^{1/2}dt$$

$$x = \sqrt{\frac{2c}{m}} \times \frac{2t^{3/2}}{3} \quad \Rightarrow \quad x \propto t^{3/2}$$

4. **(a)** When ball collides with the ground it loses its 50% of energy

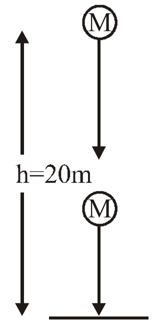
$$\therefore \frac{KE_f}{KE_i} = \frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}\quad{}^2} = \frac{1}{2}$$

$$\text{or } \frac{V_f}{V_i} = \frac{1}{\sqrt{2}}$$

$$\text{or, } \frac{\sqrt{2gh}}{\sqrt{v_0^2 + 2gh}} = \frac{1}{\sqrt{2}}$$

or, $4gh = v_0^2 + 2gh$

$\therefore\ v_0 = 20\text{ms}^{-1}$



5. **(c)** Work done in stretching the rubber-band by a distance dx is

$$dW = F\,dx = (ax + bx^2)dx$$

Integrating both sides,

$$W = \int_0^L axdx + \int_0^L bx^2dx = \frac{aL^2}{2} + \frac{bL^3}{3}$$

6. **(b)** We know that $\Delta U = -W$ for conservative forces

$$\Delta U = -\int_0^x Fdx \text{ or } \Delta U = -\int_0^x k\,xdx$$

$$\Rightarrow \quad U_{(x)} - U_{(0)} = -\frac{kx^2}{2}$$

Given $U_{(0)} = 0$

$$U_{(x)} = -\frac{kx^2}{2}$$

This is the equation of a parabola, which is symmetric to U-axis in negative direction.

7. **(d)** As we know power $P = \frac{dw}{dt}$

$$\Rightarrow \quad w = Pt = \frac{1}{2}mv^2$$

$$\text{So, } v = \sqrt{\frac{2Pt}{m}}$$

$$\text{Hence, acceleration } a = \frac{dv}{dt} = \sqrt{\frac{2P}{m}} \cdot \frac{1}{2\sqrt{t}}$$

Therefore, force on the particle at time 't'

$$= ma = \sqrt{\frac{2Km^2}{}} \cdot \frac{1}{2\sqrt{t}} = \sqrt{\frac{Km}{2t}} = \sqrt{\frac{mK}{2}}\ t^{-1/2}$$

8. **(a)** $m_1u = m_1\frac{2u}{3} + m_2v$ (By condition of linear momentum)

$\Rightarrow \frac{1}{3}m_1u = m_2v$ ...... (i)

Also $e = \frac{|v_1 - v_2|}{|u_2 - u_1|}$

$\Rightarrow v - \frac{2u}{3} = u \Rightarrow v = \frac{5}{3}u$ ...... (ii)

From (i) and (ii), $\frac{1}{3}m_1u = \frac{5}{3}m_2u \Rightarrow \frac{m_1}{m_2} = 5$

9. **(b)** As we know work done in stretching spring

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

where k = spring constant
x = extension

Case (a) If extension (x) is same,

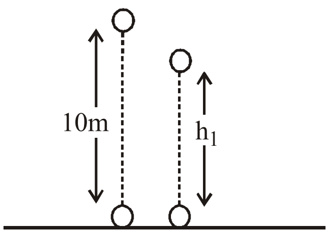
$W = \frac{1}{2}K\,x^2$

So, $W_P > W_Q$ $(\because K_P > K_Q)$

Case (b) If spring force (F) is same $W = \frac{F^2}{2K}$

So, $W_Q > W_P$

10. **(c)**



Just before impact, energy
$E = mgh = 10mg$ .... (1)
Just after impact

$E_1 = mgh - \frac{25}{100}mgh = 0.75\ mgh$

Hence, $mgh_1 = E_1$ (from given figure)

$mgh_1 = 0.75\ mg\,(10)$

$h_1 = 7.5m$

11. **(a)** Given, $h = 60m$, $g = 10\ ms^{-2}$,
Rate of flow of water = 15 kg/s
$\therefore$ Power of the falling water
$= 15\ kgs^{-1} \times 10\ ms^{-2} \times 60\ m = 900$ watt.
Loss in energy due to friction

$= 9000 \times \frac{10}{100} = 900$ watt.

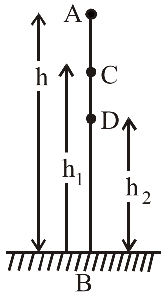
$\therefore$ Power generated by the turbine
$= (9000 - 900)$ watt $= 8100$ watt $= 8.1$ kW

12. **(c)** $t_{AB} = \sqrt{\frac{2h}{g}}$

$t_{BC} + t_{CB} = 2\sqrt{\frac{2h_1}{g}}$

$= 2\sqrt{\frac{2e^2h}{g}} = 2e\sqrt{\frac{2h}{g}}$

$t_{BD} + t_{DB} = 2e^2\sqrt{\frac{2h}{g}}$



$\therefore$ Total time taken by the body in coming to rest

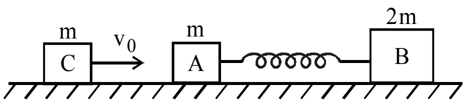
$= \sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}} + 2e^2\sqrt{\frac{2h}{g}} + ...$

$= \sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}}\,[1 + e + e^2 + ...]$

$= \sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}} \times \frac{1}{1-e} = \sqrt{\frac{2h}{g}}\left[\frac{1+e}{1-e}\right] = t\left(\frac{1+e}{1-e}\right)$

13. **(d)** When C strikes A

$\frac{1}{2}mv_0^2 = \frac{1}{2}mv'^2 + \frac{1}{2}kx_0^2$ (v' = velocity of A)



$kx_0^2 = m(v_0^2 - v'^2)$ .... (i)

$\frac{1}{2}2mv'^2 = \frac{1}{2}kx_0^2$

(When A and B Block attains K.E.)

$\therefore \frac{1}{2}kx_0^2 = mv'^2$ .... (ii)

From (i) and (ii),

$kx_0^2 = mv_0^2 - mv'^2 = mv_0^2 - \frac{k}{2}x_0^2$

$\Rightarrow kx_0^2 + \frac{k}{2}x_0^2 = mv_0^2$

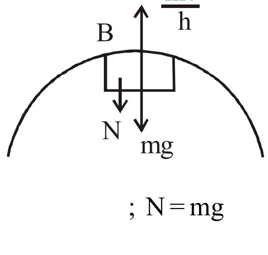
$\frac{3}{2}kx_0^2 = mv_0^2 \therefore k = \frac{2}{3}m\frac{v_0^2}{x_0^2}$

14. **(a)** By conservation of energy

$mg\,(3h) = mg\,(2h) + \frac{1}{2}mv^2$ (v = velocity at B)

$mgh = \frac{1}{2}mv^2$; $v = \sqrt{2gh}$

From free body diagram of block at B



; $N = mg$

15. (d) Given force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$

According to Newton's second law of motion,

$$m\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j} \quad (m = 1\text{ kg})$$

$$\Rightarrow \quad \int_0^{\vec{v}} d\vec{v} = \int_0^t \left(2t\hat{i} + 3t^2\hat{j}\right)dt$$

$$\Rightarrow \quad \vec{v} = t^2\hat{i} + t^3\hat{j}$$

Power P = $\vec{F}\cdot\vec{v} = (2t\,\hat{i} + 3t^2\hat{j})\cdot(t^2\hat{i} + t^3\hat{j})$
$= (2t^3 + 3t^5)$W

16. (a) According to conservation of linear momentum,
$M_bV_b = M_{bl}V_{bl} + M_bV_b{}^1$ ....(i)
where v_b is velocity of bullet before collision v_b^1 velocity of bullet after collision and v_{bl} is the velocity of block.
K.E. of block = P.E. of block

$$\frac{1}{2}M_{bl}V_{bl}^2 = M_{bl}\,gh\ (h = 0.2\text{m})$$

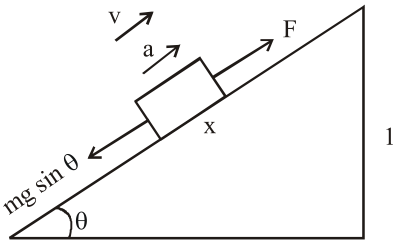
Solving we get $V_{bl} = 2\text{ms}^{-1}$
Now from eq (i)

$$20 \times 10^{-3} \times 600 = 4 \times 2 + 20 \times 10^{-3}\ V_b^1$$

Solving we get $V_b^1 = 200$ m/s

17. (d) $\sin\theta = \dfrac{1}{x}$

From free body diagram of the body



$F - mg\sin\theta = ma$

$$F = m\,(g\sin\theta + a) = m\left(\frac{g}{x} + a\right) \quad ....(1)$$

Displacement of the body till its velocity reaches v

$$v^2 = 0 + 2as \ \Rightarrow\ s = \frac{v^2}{2a}$$

Now, work done = F s cos 0° $= \dfrac{m}{x}(g + ax) \times \dfrac{v^2}{2a}$

$$= \frac{mv^2}{2ax}(g + ax)$$

18. (a) Velocity is maximum when K.E. is maximum
For minimum. P.E.,

$$\frac{dV}{dx} = 0 \Rightarrow x^3 - x = 0 \Rightarrow x = \pm 1$$

$$\Rightarrow \text{Min. P.E.} = \frac{1}{4} - - \quad -$$

K.E.$_{(max.)}$ + P.E.$_{(min.)}$ = 2 (Given)

$$\therefore \text{K.E.}_{(max.)} = 2 + \frac{1}{4} = \frac{9}{4}$$

$$\text{K.E.}_{max.} = \frac{1}{2}mv_{max.}^2$$

$$\Rightarrow \frac{1}{2} \times 1 \times v_{max.}^2 = \frac{9}{4} \Rightarrow v_{max.} = \frac{3}{\sqrt{2}}$$

19. (b) Constant power of car $P_0 = F.v = ma.v$

$$P_0 = m\frac{dv}{dt}.v$$

$P_0 dt = mvdv$ Integrating

$$P_0.t = \frac{mv^2}{2}$$

$$v = \sqrt{\frac{2P_0 t}{m}}$$

$\because P_0$, m and 2 are constant

$\therefore \quad v \propto \sqrt{t}$

20. (b) Let initial velocity of the bullet be v.
By linear momentum conservation

$$\frac{m}{2}v = \left(\frac{m}{2} + m\right)v_1$$

(v_1 = combined velocity)

$$v_1 = \frac{v}{3} \quad ....(1)$$

retardation = μg

$$0 = \left(\frac{v}{3}\right)^2 - 2\mu gd \ \Rightarrow v = 3\sqrt{2\mu gd}$$

21. (a) $x = 3t - 4t^2 + t^3$

$$\frac{dx}{dt} = 3 - 8t + 3t^2$$

$$\text{Acceleration } = \frac{d^2x}{dt^2} = -8 + 6t$$

Acceleration after 4 sec
$= -8 + 6 \times 4 = 16\text{ ms}^{-2}$
Displacement in 4 sec
$= 3 \times 4 - 4 \times 4^2 + 4^3 = 12$ m
$\therefore$ Work = Force × displacement
= Mass × acc. × disp.
$= 3 \times 10^{-3} \times 16 \times 12 = 576$ mJ

22. (b) $v^2 = u^2 + 2gh = (10)^2 + 2\times10\times19.5 = 490$
K.E. at the ground

$$= \frac{1}{2}mv^2 = \frac{1}{2}\times\frac{5}{1000}\times490 = \frac{49}{40}\text{ J}$$

$$\text{P.E.} = mgh = \frac{5}{1000}\times10\times\left(\frac{-50}{100}\right) = -\frac{1}{40}\text{ J}$$

$$\frac{49}{40} - \left(-\frac{1}{40}\right) = \frac{50}{40} = 1.25\text{J}$$

23. (c) Volume of water to raise $= 22380\ l = 22380 \times 10^{-3} m^3$

$$P = \frac{mgh}{t} = \frac{V\rho gh}{t} \Rightarrow t = \frac{V\rho gh}{P}$$

$$t = \frac{22380 \times 10^{-3} \times 10^{3} \times 10 \times 10}{10 \times 746} = 15 \text{ min}$$

24. (c) Change in momentum along the wall

$= mv \cos 60^\circ - mv \cos 60^\circ = 0$

Change in momentum perpendicular to the wall

$= mv \sin 60^\circ - (-mv \sin 60^\circ) \quad = 2mv \sin 60^\circ$

$$\therefore \text{Applied force} = \frac{\text{Change in momentum}}{\text{Time}}$$

$$= \frac{2\ mv \sin 60^\circ}{0.20}$$

$$= \frac{2 \times 3 \times 10 \times \sqrt{3}}{2 \times 0.2} = 50 \times 3\sqrt{3}$$

$= 150\sqrt{3}$ newton

25. (b) Let the block compress the spring by x before stopping.

Kinetic energy of the block = (P.E of compressed spring) + work done against friction.

$$\frac{1}{2} \times 2 \times (4)^2 = \frac{1}{2} \times 10{,}000 \times x^2 + 15 \times x$$

$$10{,}000\, x^2 + 30x - 32 = 0$$

$$\Rightarrow 5000x^2 + 15x - 16 = 0$$

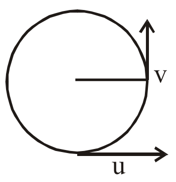
$$\therefore \quad x = \frac{-15 \pm \sqrt{(15)^2 - 4 \times (5000)(-16)}}{2 \times 5000}$$

$= 0.055\text{m} = 5.5\text{cm}.$

26. (b) $W_{mg} = \Delta K \Rightarrow - mg\,\ell = \frac{1}{2} mv^2 - \frac{1}{2} mu^2$

or $mv^2 = m(u^2 - 2 g\,\ell)$ or $v = \sqrt{u^2 - 2g\ell}\ \hat{j}$

$\vec{u} = u\,\hat{i}$



$$\therefore \vec{v} - \vec{u} = \sqrt{u^2 - 2g\ell}\ \hat{j} - u\,\hat{i}$$

$$\therefore |\vec{v} - \vec{u}| = [(u^2 - 2g\ell) + u^2]^{1/2} = \sqrt{2(u^2 - g\ell)}$$

27. (a) Amount of water flowing per second from the pipe

$$= \frac{m}{time} = \frac{m}{\ell} \cdot \frac{\ell}{t} = \left(\frac{m}{\ell}\right) v$$

Power = K.E. of water flowing per second

$$= \frac{1}{2}\left(\frac{m}{\ell}\right) v \cdot v^2$$

$$= \frac{1}{2}\left(\frac{m}{\ell}\right) v^3$$

$$= \frac{1}{2} \times 100 \times 8 = 400\,W$$

28. (a) Velocity of 50 kg. mass after 5 sec of projection

$v = u - gt = 100 - 9.8 \times 5 = 51 m/s$

At this instant momentum of body is in upward direction

$p_{initial} = 50 \times 51 = 2550\, kg\ m/s$

After breaking 20 kg piece travels upwards with 150 m/s let the speed of 30 kg mass is v

$p_{final} = 20 \times 150 + 30 \times v$

By the law of conservation of momentum

$p_{\text{initial}} = p_{\text{final}}$

$\Rightarrow 2550 = 20 \times 150 + 30 \times v \Rightarrow v = -15 m/s$

i.e. it moves in downward direction.

29. (d) K.E. $= \frac{1}{2} mv^2$

Further, $v^2 = u^2 + 2as = 0 + 2ad = 2ad$

$= 2(F/m)d$

Hence, K.E. $= \frac{1}{2} m \times 2(F/m)d = Fd$

or, K.E. acquired = Work done

$= F \times d$ = constant.

i.e., it is independent of mass m.

30. (a) Gravitational potential energy of ball gets converted into elastic potential energy of the spring.

$$mg(h + d) = \frac{1}{2} kd^2$$

Net work done $= mg(h + d) - \frac{1}{2} kd^2 = 0$