DPP - Daily Practice Problems

Chapter-wise Sheets

Date : | Start Time : | End Time :

PHYSICS

CP05

SYLLABUS : Work, Energy and Power

Max. Marks : 180 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

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. A cord is used to lower vertically a block of mass M, a distance d at a constant downward acceleration of g/4. The work done by the cord on the block is

(a) $Mg\frac{d}{4}$ (b) $3Mg\frac{d}{4}$ (c) $-3Mg\frac{d}{4}$ (d) Mg d

6. A rubber ball is dropped from a height of 5m on a plane, where the acceleration due to gravity is not shown. On bouncing it rises to 1.8 m. The ball loses its velocity on bouncing by a factor of

(a) $\frac{16}{25}$ (b) $\frac{2}{5}$ (c) $\frac{3}{5}$ (d) $\frac{9}{25}$

7. A ball of mass m moving with a constant velocity strikes against a ball of same mass at rest. If e = coefficient of restitution, then what will be the ratio of velocity of two balls after collision?

(a) $\frac{1-e}{1+e}$ (b) $\frac{e-1}{e+1}$ (c) $\frac{1+e}{1-e}$ (d) $\frac{2+e}{e-1}$

8. 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) $\sqrt{\frac{mk}{2}}t^{-1/2}$

RESPONSE GRID					
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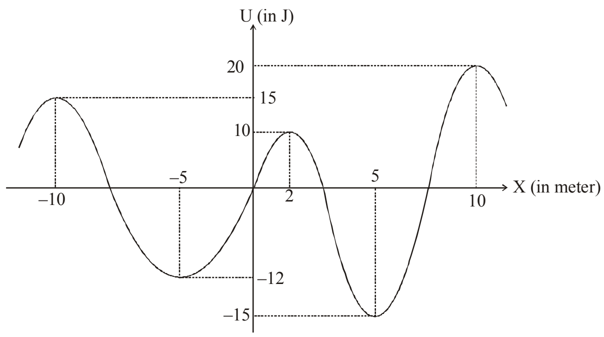
Space for Rough Work

9. A body of mass 2 kg moving under a force has relation between displacement x and time t as $x = \frac{t^3}{3}$ where x is in metre and t is in sec. The work done by the body in first two second will be
(a) 1.6 joule (b) 16 joule
(c) 160 joule (d) 1600 joule

10. A sphere of mass 8m collides elastically (in one dimension) with a block of mass 2m. If the initial energy of sphere is E. What is the final energy of sphere?
(a) 0.8 E (b) 0.36 E
(c) 0.08 E (d) 0.64 E

11. 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) $W_P = W_Q$; $W_P > W_Q$

12. In the figure, the variation of potential energy of a particle of mass m = 2 kg is represented w.r.t. its x-coordinate. The particle moves under the effect of this conservative force along the x-axis.

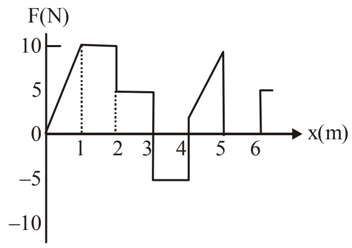


If the particle is released at the origin then
(a) it will move towards positive x-axis
(b) it will move towards negative x-axis
(c) it will remain stationary at the origin
(d) its subsequent motion cannot be decided due to lack of information

13. The potential energy of a certain spring when stretched through distance S is 10 joule. The amount of work done (in joule) that must be done on this spring to stretch it through an additional distance s, will be
(a) 20 (b) 10 (c) 30 (d) 40

14. A force applied by an engine of a train of mass 2.05×10^6 kg changes its velocity from 5m/s to 25 m/s in 5 minutes. The power of the engine is
(a) 1.025 MW (b) 2.05 MW
(c) 5 MW (d) 6 MW

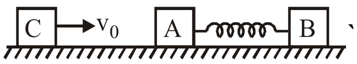
15. The relationship between the force F and position x of a body is as shown in figure. The work done in displacing the body form x = 1 m to x = 5 m will be



(a) 30 J (b) 15 J (c) 25 J (d) 20 J

16. 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

17. 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) $\frac{2}{3}\frac{mv_0^2}{x_0^2}$

18. Two springs of force constants 300 N/m (Spring A) and 400 N/m (Spring B) are joined together in series. The combination is compressed by 8.75 cm. The ratio of energy stored in A and B is $\frac{E_A}{E_B}$. Then $\frac{E_A}{E_B}$ is equal to :
(a) $\frac{4}{3}$ (b) $\frac{16}{9}$ (c) $\frac{3}{4}$ (d) $\frac{9}{16}$

19. 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

20. 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

RESPONSE GRID					
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Space for Rough Work

21. A body of mass m kg is ascending on a smooth inclined plane of inclination $\theta\left(\sin\theta = \frac{1}{x}\right)$ 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) $\frac{mv^2}{2ax}(g + xa)$

22. 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) $t\left[\frac{1-e}{1+e}\right]$

23. 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

24. 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

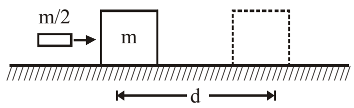
24. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0. The instantaneous velocity of this car is proportional to :

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

25. When a 1.0kg mass hangs attached to a spring of length 50 cm, the spring stretches by 2 cm. The mass is pulled down until the length of the spring becomes 60 cm. What is the amount of elastic energy stored in the spring in this condition. if $g = 10\ m/s^2$.

(a) 1.5 joule (b) 2.0 joule (c) 2.5 joule (d) 3.0 joule

26. 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

27. 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

28. A particle of mass m_1 moving with velocity v strikes with a mass m_2 at rest, then the condition for maximum transfer of kinetic energy is

(a) $m_1 >> m_2$ (b) $m_2 >> m_2$ (c) $m_1 = m_2$ (d) $m_1 = 2m_2$

29. A mass *m* is moving with velocity v collides inelastically with a bob of simple pendulum of mass m and gets embedded into it. The total height to which the masses will rise after collision is

(a) $\frac{v^2}{8g}$ (b) $\frac{v^2}{4g}$ (c) $\frac{v^2}{2g}$ (d) $\frac{2v^2}{g}$

30. 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

31. A particle of mass m_1 is moving with a velocity v_1 and another particle of mass m_2 is moving with a velocity v_2. Both of them have the same momentum but their different kinetic energies are E_1 and E_2 respectively. If $m_1 > m_2$ then

(a) $E_1 = E_2$ (b) $E_1 < E_2$ (c) $\frac{E_1}{E_2} = \frac{m_1}{m_2}$ (d) $E_1 > E_2$

32. A block of mass 10 kg, moving in x direction with a constant speed of $10\ ms^{-1}$, is subject to a retarding force $F = 0.1 \times J\,m$ during its travel from x = 20 m to 30 m. Its final KE will be :

(a) 450 J (b) 275 J (c) 250 J (d) 475 J

33. Identify the false statement from the following

(a) Work-energy theorem is not independent of Newton's second law.
(b) Work-energy theorem holds in all inertial frames.
(c) Work done by friction over a closed path is zero.
(d) No potential energy can be associated with friction.

34. A one-ton car moves with a constant velocity of $15\ ms^{-1}$ on a rough horizontal road. The total resistance to the motion of the car is 12% of the weight of the car. The power required to keep the car moving with the same constant velocity of $15ms^{-1}$ is [Take $g = 10\ ms^{-2}$]

(a) 9 kW (b) 18 kW (c) 24 kW (d) 36 kW

35. A ball is released from the top of a tower. The ratio of work done by force of gravity in first, second and third second of the motion of the ball is

(a) 1 : 2 : 3 (b) 1 : 4 : 9 (c) 1 : 3 : 5 (d) 1 : 5 : 3

RESPONSE GRID					
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	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ

Space for Rough Work

36. Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v along x-axis. After collision B has a velocity $\frac{v}{2}$ in a direction perpendicular to the original direction. The mass A moves after collision in the direction.
(a) Same as that of B
(b) Opposite to that of B
(c) $\theta = \tan^{-1}(1/2)$ to the x-axis
(d) $\theta = \tan^{-1}(-1/2)$ to the x-axis

37. 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

38. 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

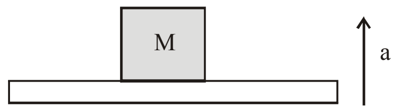
39. A uniform chain of length 2 m is kept on a table such that a length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg. What is the work done in pulling the entire chain on the table ?
(a) 12 J (b) 3.6 J (c) 7.2 J (d) 1200 J

40. A mass 'm' moves with a velocity 'v' and collides inelastically with another identical mass. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion. Find the speed of the 2nd mass after collision.

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

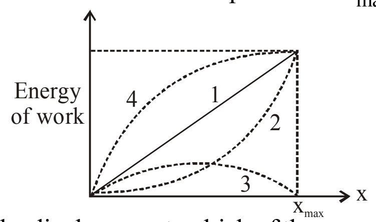
41. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is
(a) 20 m/s (b) 40 m/s (c) $10\sqrt{30}$ m/s (d) 10 m/s

42. A block of mass M is kept on a platform which is accelerated upward with a constant acceleration 'a' during the time interval T. The work done by normal reaction between the block and platform is



(a) $-\frac{MgaT^2}{2}$ (b) $\frac{1}{2}M(g+a)aT^2$
(c) $\frac{1}{2}Ma^2T$ (d) Zero

43. A spring lies along an x axis attached to a wall at one end and a block at the other end. The block rests on a frictionless surface at x = 0. A force of constant magnitude F is applied to the block that begins to compress the spring, until the block comes to a maximum displacement x_{max}.



During the displacement, which of the curves shown in the graph best represents the kinetic energy of the block ?
(a) 1 (b) 2 (c) 3 (d) 4

44. 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

45. 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					
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DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP05 - PHYSICS			
Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	50	Qualifying Score	70
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

DPP/CP05

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, $M = 10g = \frac{10}{1000}$kg

radius of circle R = 6.4 cm

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

acceleration a_t = ?

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

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

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

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

Now, using

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

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

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

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

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

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

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

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

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

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

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

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

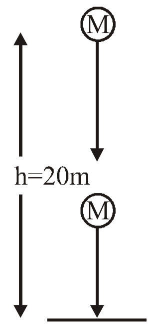
$$\therefore \frac{KE_f}{KE_i} = \frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}mV_i^2} = \frac{1}{2}$$

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

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

$$\text{or, } 4gh = v_0^2 + 2gh$$

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



5. (c) As the cord is trying to hold the motion of the block, work done by the cord is negative.

$$W = -M(g-a)d = -M\left(g - \frac{g}{4}\right)d = \frac{-3Mgd}{4}$$

6. (b) According to principle of conservation of energy

Loss in potential energy = Gain in kinetic energy

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

If h_1 and h_2 are initial and final heights, then

$$v_1 = \sqrt{2gh_1}, v_2 = \sqrt{2gh_2}$$

Loss in velocity

$$\Delta v = v_1 - v_2 = \sqrt{2gh_1} - \sqrt{2gh_2}$$

$\therefore$ Fractional loss in velocity

$$= \frac{\Delta v}{v_1} = \frac{\sqrt{2gh_1} - \sqrt{2gh_2}}{\sqrt{2gh_1}} = 1 - \sqrt{\frac{h_2}{h_1}}$$

$$= 1 - \sqrt{\frac{1.8}{5}} = 1 - \sqrt{0.36} = 1 - 0.6 = 0.4 = \frac{2}{5}$$

7. (a) As $u_2 = 0$ and $m_1 = m_2$, therefore from

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ we get $u_1 = v_1 + v_2$

$$\text{Also, } e = \frac{v_2 - v_1}{u_1} = \frac{v_2 - v_1}{v_2 + v_1} = \frac{1 - v_1/v_2}{1 + v_1/v_2},$$

$$\text{which gives } \frac{v_1}{v_2} = \frac{1-e}{1+e}$$

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

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

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

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

Therefore, force on the particle at time 't'

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

9. **(b)** $x = \frac{t^3}{3} \Rightarrow \frac{dx}{dt} = \frac{3t^2}{3} = t^2 \quad \Rightarrow v = t^2$

when, $t = 2$ sec, $v = t^2 = (2)^2 = 4$ m/s

Work done = K.E. acquired $= \frac{1}{2} mv^2$

$$= \frac{1}{2} \times (2) \times (4)^2 = 16\,J$$

10. **(b)** For elastic collision in one dimension

$$v_1 = \frac{2m_2u_2}{m_1 + m_2} + \frac{(m_1 - m_2)u_1}{(m_1 + m_2)}$$

As mass 2m, is at rest, So $u_2 = 0$

$$\Rightarrow \quad v_1 = \frac{(8m - 2m)u}{8m + 2m} = \frac{3}{5}u$$

Final energy of sphere = $(K.E.)_f$

$$= \frac{1}{2}(8m)\left(\frac{3u}{5}\right)^2 = \frac{1}{2}(8m)u^2 \times \left(\frac{3}{5}\right)^2$$

$$= \frac{9}{25}E = 0.36\,E$$

11. **(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, $W_P > W_Q \qquad (\because K_P > K_Q)$

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

So, $W_Q > W_P$

12. **(b)** If the particle is released at the origin, it will try to go in the direction of force. Here $\frac{dU}{dx}$ is positive and hence force is negative, as a result it will move towards –ve x-axis.

13. **(c)** The potential energy of a spring is given by,

$U = \frac{1}{2}kx^2 \Rightarrow 10\,J = \frac{1}{2}ks^2 \qquad$ .... (i)

The potential energy stored when stretched

through $(2s) = \frac{1}{2}k(2s^2) = \frac{1}{2}ks^2 \times 4$

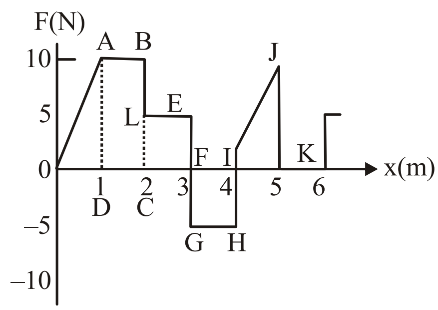
Substituting from (i)
P.E. = 40 J.
But to increase 's' to '2s', the work done
= 40 – 10 = 30 J.

14. **(b)** $\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{\frac{1}{2}m(v^2 - u^2)}{t}$

$$P = \frac{1}{2} \times \frac{2.05 \times 10^6 \times \left[(25)^2 - (5^2)\right]}{5 \times 60}$$

$P = 2.05 \times 10^6$ W = 2.05 MW

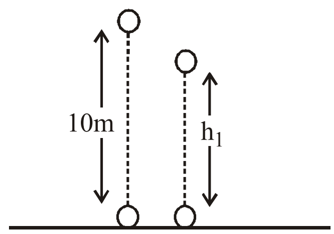
15. **(b)** Work done = Area under F-x graph
= area of rectangle ABCD + area of rectangle LCFE
+ area of rectangle GFIH + area of triangle IJK



$= (2–1) \times (10 – 0) + (3 – 2)\,(5 – 0)\;\;(4 – 3)\,(–5 – 0)$

$+ \frac{1}{2}(5 - 4)(10 - 0) = 15\,J$

16. **(c)**



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

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

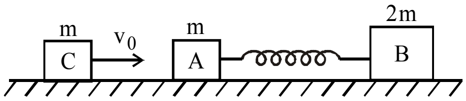
Hence, $mgh_1 = E_1 \qquad$ (from given figure)

$mgh_1 = 0.75\, mg (10)$

$h_1 = 7.5 m$

17. (d) When C strikes A

$\frac{1}{2} m v_0^2 = \frac{1}{2} m v'^2 + \frac{1}{2} k x_0^2$ (v' = velocity of A)



$k x_0^2 = m(v_0^2 - v'^2)$ .... (i)

$\frac{1}{2} 2 m v'^2 = \frac{1}{2} k x_0^2$

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

$\therefore \quad \frac{1}{2} k x_0^2 = m v'^2$ .... (ii)

From (i) and (ii),

$k x_0^2 = m v_0^2 - m v'^2 = m v_0^2 - \frac{k}{2} x_0^2$

$\Rightarrow \; k x_0^2 + \frac{k}{2} x_0^2 = m v_0^2$

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

18. (a) Given : $k_A = 300\, N/m, \; k_B = 400\, N/m$

Let the combination of springs is compressed by force F. Spring A is compressed by x. Therefore compression in spring B

$x_B = (8.75 - x)$ cm

$F = 300 \times x = 400(8.75 - x)$

Solving we get, x = 5 cm

$x_B = 8.75 - 5 = 3.75 cm$

$$\frac{E_A}{E_B} = \frac{\frac{1}{2} k_A (x_A)^2}{\frac{1}{2} k_B (x_B)^2} = \frac{300 \times (5)^2}{400 \times (3.75)^2} = \frac{4}{3}$$

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

According to Newton's second law of motion,

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

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

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

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

$= (2t^3 + 3t^5)W$

20. (a) According to conservation of linear momentum,

$M_b V_b = M_{bl} V_{bl} + M_b V_b^1$ ....(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

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

Solving we get $V_{bl} = 2 ms^{-1}$

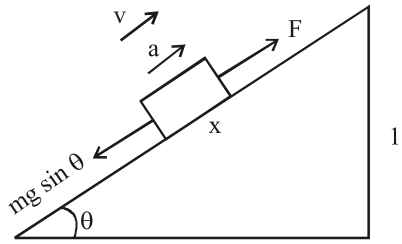
Now from eq (i)

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

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

21. (d) $\sin\theta = \frac{1}{x}$

From free body diagram of the body



$F - mg \sin\theta = ma$

$F = m(g \sin\theta + a) = m\left(\frac{g}{x} + a\right)$ .... (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° $= \frac{m}{x}(g + ax) \times \frac{v^2}{2a}$

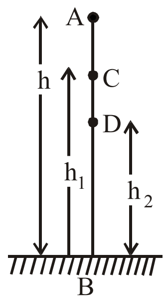
$= \frac{mv^2}{2ax}(g + ax)$

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

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

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

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



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

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

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

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

23. (a) Velocity is maximum when K.E. is maximum

For minimum. P.E.,

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

$$\Rightarrow \text{Min. P.E.} = \frac{1}{4} - \frac{1}{2} = -\frac{1}{4}\text{ J}$$

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

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

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

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

24. (a) Given, $h = 60$m, $g = 10$ ms^{-2},

Rate of flow of water = 15 kg/s

∴ Power of the falling water

= 15 kgs^{-1} × 10 ms^{-2} × 60 m = 900 watt.

Loss in energy due to friction

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

∴ Power generated by the turbine

= (9000 – 900) watt = 8100 watt = 8.1 kW

24. (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)

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

retardation = μg

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

25. (c) Force constant of a spring

$$k = \frac{F}{x} = \frac{mg}{x} = \frac{1 \times 10}{2 \times 10^{-2}} \Rightarrow k = 500 N/m$$

Increment in the length = 60 – 50 = 10 cm

$$U = \frac{1}{2}kx^2 = \frac{1}{2}500\left(10 \times 10^{-2}\right)^2 = 2.5J$$

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

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

$P_0 dt = mvdv$ Integrating

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

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

∵ P_0, m and 2 are constant

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

27. (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

$= -8 + 6 \times 4 = 16$ ms^{-2}

Displacement in 4 sec

$= 3 \times 4 - 4 \times 4^2 + 4^3 = 12$ m

∴ Work = Force × displacement

= Mass × acc. × disp.

$= 3 \times 10^{-3} \times 16 \times 12 = 576$ mJ

28. (c) $K_i = \frac{1}{2}m_1u_1^2$,

$$K_f = \frac{1}{2}m_1v_1^2, v_1 = \frac{m_1 - m_2}{m_1 + m_2}u_1$$

Fractional loss

$$\frac{K_i - K_f}{K_i} = \frac{\frac{1}{2}m_1u_1^2 - \frac{1}{2}m_1v_1^2}{\frac{1}{2}m_1u_1^2}$$

$$= 1 - \frac{v_1^2}{u_1^2} = 1 - \frac{(m_1 - m_2)^2}{(m_1 + m_2)^2} = \frac{4m_1m_2}{(m_1 + m_2)^2}$$

$$(m_2 = m; \; m_1 = nm); \quad = \frac{4n}{(1+n)^2}$$

Energy transfer is maximum when $K_f = 0$

$$\frac{4n}{(1+n)^2} = 1 \Rightarrow 4n = 1 + n^2 + 2n \Rightarrow n^2 + 1 - 2n = 0$$

$$(n-1)^2 = 0 \qquad n = 1 \text{ ie. } m_2 = m, \; m_1 = m$$

Transfer will be maximum when both masses are equal and one is at rest.

29. (a) For inelastic collision, linear momentum is conserved

$$\Rightarrow mv_1 = 2mv_2 \Rightarrow v_2 = \frac{v_1}{2}$$

Loss in K.E. = Gain in P.E.

$$= \frac{1}{2}mv_1^2 - \frac{1}{2}(2m)v_2^2 = 2mgh$$

$$\Rightarrow 4\text{ mgh} = mv_1^2 - \frac{mv_1^2}{2} = \frac{mv_1^2}{2} = \frac{mv^2}{2}$$

$$\Rightarrow h = \frac{v^2}{8g}$$

30. **(c)** Volume of water to raise $= 22380\ l = 22380\times10^{-3}m^3$

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

$$t=\frac{22380\times10^{-3}\times10^{3}\times10\times10}{10\times746}=15\ \text{min}$$

31. **(b)** $E=\frac{p^2}{2m}$

or, $E_1=\frac{p_1^2}{2m_1}, E_2=\frac{p_2^2}{2m_2}$

or, $m_1=\frac{p_1^2}{2E_1}, m_2=\frac{p_2^2}{2E_2}$

$m_1>m_2\Rightarrow\frac{m_1}{m_2}>1$

$\therefore \frac{p_1^2E_2}{E_1P_2^2}>1\Rightarrow\frac{E_2}{E_1}>1 \quad [\because p_1=p_2]$

or, $E_2>E_1$

32. **(d)** From, F = ma

$$a=\frac{F}{m}=\frac{0.1x}{10}=0.01x=V\frac{dV}{dx}$$

So, $\int_{V_1}^{V_2} VdV=\int_{20}^{30}\frac{x}{100}dx$

$$-\left.\frac{V^2}{2}\right|_{V_1}^{V_2}=\left.\frac{x^2}{200}\right|_{20}^{30}=\frac{30\times30}{200}-\frac{20\times20}{200}$$

$=4.5-2=2.5$

$=\frac{1}{2}m\left(V_2^2-V_1^2\right)=10\times2.5\ J=-25J$

Final K.E.

$=\frac{1}{2}mV_2^2=\frac{1}{2}mV_1^2-25=\frac{1}{2}\times10\times10\times10-25$

$=500-25=475\ J$

33. **(c)** Friction is a non-conservative force. Work done by a non-conservative force over a closed path is not zero.

34. **(b)** $F=\frac{12}{100}\times1000\times10\ N=1200\ N$

$P=Fv=1200\ N\times15\ ms^{-1}=18\ kW.$

35. **(c)** When the ball is released from the top of tower then ratio of distances covered by the ball in first, second and third second

$h_I:h_{II}:h_{III}=1:3:5:$ [Because $h_n\propto(2n-1)$]

$\therefore$ Ratio of work done $mgh_I:mgh_{II}:mgh_{III}=1:3:5$

36. **(c)** m_2 $\quad$ m_1

(B) → v $\quad$ (A)

$u=0$

conservation of linear momentum along x-direction

$m_2v=m_1v_x \Rightarrow \frac{m_2v}{m_1}=v_x$

along y-direction

$m_2\times\frac{v}{2}=m_1v_y \Rightarrow v_y=\frac{m_2v}{2m_1}$

Note: Let A moves in the direction, which makes an angle θ with initial direction i.e.

$$\tan\theta=\frac{v_y}{v_x}=\frac{m_2v}{2m_1}\Big/\frac{m_2v}{m_1}$$

$$\tan\theta=\frac{1}{2}$$

$\Rightarrow \quad \theta=\tan^{-1}\left(\frac{1}{2}\right)$ to the x-axis.

37. **(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.

$\frac{1}{2}\times2\times(4)^2=\frac{1}{2}\times10{,}000\times x^2+15\times x$

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

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

$$\therefore\ x=\frac{-15\pm\sqrt{(15)^2-4\times(5000)(-16)}}{2\times5000}$$

$=0.055m=5.5cm.$

38. **(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

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

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

$=\frac{1}{2}\times100\times8=400\ W$

39. **(b)** Mass of over hanging chain $m'=\frac{4}{2}\times(0.6)$kg

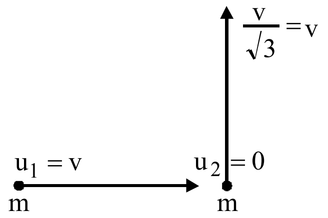
Let at the surface PE = 0

C.M.of hanging part = 0.3 m below the table

$U_i=-m'gx=-\frac{4}{2}\times0.6\times10\times0.30$

$\Delta U=m'gx=3.6J=$ Work done in putting the entire chain on the table.

40. **(d)**



In x-direction : $mv + 0 = m(0) + m(v_2)_x$

In y-direction : $0 + 0 = m\left(\frac{v}{\sqrt{3}}\right) + m(v_2)_y$ is

$\Rightarrow (v_2)_y = \frac{v}{\sqrt{3}}$ and $(v_2)_x = v$

$\therefore \quad v_2 = \sqrt{\left(\frac{v}{\sqrt{3}}\right)^2 + v^2}$

$\Rightarrow \quad v_2 = \sqrt{\frac{v^2}{3} + v^2} = v\sqrt{\frac{4}{3}} = \frac{2v}{\sqrt{3}}$

Alternative method : In x-direction,

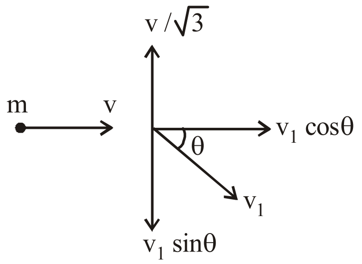
$mv = mv_1 \cos\theta$ ...(1)

where v_1 is the velocity of second mass

In y-direction,

$0 = \frac{mv}{\sqrt{3}} - mv_1 \sin\theta$

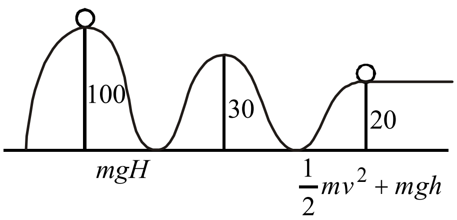
or $\quad m_1 v_1 \sin\theta = \frac{mv}{\sqrt{3}}$ ...(2)



Squaring and adding eqns. (1) and (2)

$v_1^2 = v^2 + \frac{v^2}{\sqrt{3}} \Rightarrow v_1 = \frac{2}{\sqrt{3}} v$

41. **(b)**

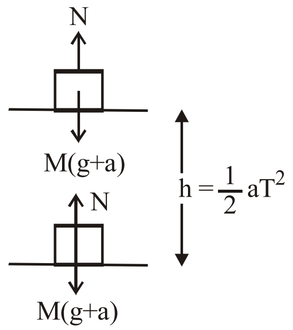


Using conservation of energy,

$m(10 \times 100) = m\left(\frac{1}{2}v^2 + 10 \times 20\right)$

or $\frac{1}{2}v^2 = 800$ or $v = \sqrt{1600} = 40$ m/s

42. **(b)**



Work done by normal reaction

$= Nh = M(g+a)\frac{1}{2}aT^2 = \frac{1}{2}M(g+a)aT^2$

43. **(c)** Applying W-E theorem on the block for any compression x :

$W_{ext} + W_g + W_{spring} = \Delta KE$

$\Rightarrow \quad Fx + 0 - \frac{1}{2}Kx^2 = \frac{1}{2}mv^2$

$\Rightarrow$ KE vs x is inverted parabola.

44. **(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.

45. **(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 $= mg(h+d) - \frac{1}{2}kd^2 = 0$