Chapter 5. Work, Energy and Power

1. Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of 50 m s^{-1}. Take 'g' constant with a value 10 m s^{-2}. The work done by the (i) gravitational force and the (ii) resistive force of air is
(a) (i) 1.25 J (ii) −8.25 J
(b) (i) 100 J (ii) 8.75 J
(c) (i) 10 J (ii) −8.75 J
(d) (i) −10 J (ii) −8.25 J
(NEET 2017)

2. A bullet of mass 10 g moving horizontally with a velocity of 400 m s^{-1} strikes a wood block of mass 2 kg which is suspended by light inextensible string of length 5 m. As a result, the centre of gravity of the block found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges out horizontally from the block will be
(a) 100 m s^{-1} (b) 80 m s^{-1}
(c) 120 m s^{-1} (d) 160 m s^{-1}
(NEET-II 2016)

3. Two identical balls A and B having velocities of 0.5 m s^{-1} and −0.3 m s^{-1} respectively collide elastically in one dimension. The velocities of B and A after the collision respectively will be
(a) −0.5 m s^{-1} and 0.3 m s^{-1}
(b) 0.5 m s^{-1} and −0.3 m s^{-1}
(c) −0.3 m s^{-1} and 0.5 m s^{-1}
(d) 0.3 m s^{-1} and 0.5 m s^{-1}
(NEET-II 2016, 1994, 1991)

4. A particle moves from a point $(-2\hat{i}+5\hat{j})$ to $(4\hat{j}+3\hat{k})$ when a force of $(4\hat{i}+3\hat{j})$ N is applied. How much work has been done by the force ?
(a) 8 J (b) 11 J (c) 5 J (d) 2 J
(Neet-II 2016)

5. 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) 0.18 m/s^2 (b) 0.2 m/s^2
(c) 0.1 m/s^2 (d) 0.15 m/s^2
(NEET-I 2016)

6. 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 along x and y axis. What power will be developed by the force at the time t?
(a) $(2t^3+3t^4)$ W (b) $(2t^3+3t^5)$ W
(c) $(2t^2+3t^3)$ W (d) $(2t^2+4t^4)$ W
(NEET-I 2016)

7. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?
(a) $\sqrt{3gR}$ (b) $\sqrt{5gR}$
(c) $\sqrt{gR}$ (d) $\sqrt{2gR}$
(NEET-I 2016)

8. Two particles A and B, move with constant velocities $\vec{v}_1$ and $\vec{v}_2$. At the initial moment their position vectors are $\vec{r}_1$ and $\vec{r}_2$ respectively. The condition for particles A and B for their collision is
(a) $\vec{r}_1\times\vec{v}_1=\vec{r}_2\times\vec{v}_2$ (b) $\vec{r}_1-\vec{r}_2=\vec{v}_1-\vec{v}_2$
(c) $\dfrac{\vec{r}_1-\vec{r}_2}{|\vec{r}_1-\vec{r}_2|}=\dfrac{\vec{v}_2-\vec{v}_1}{|\vec{v}_2-\vec{v}_1|}$ (d) $\vec{r}_1\cdot\vec{v}_1=\vec{r}_2\cdot\vec{v}_2$
(2015)

9. The heart of a man pumps 5 litres of blood through the arteries per minute at a pressure of 150 mm of mercury. If the density of mercury be 13.6×10^3 kg/m^3 and g = 10 m/s^2 then the power (in watt) is
(a) 3.0 (b) 1.50 (c) 1.70 (d) 2.35
(2015)

10. A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0. It collides with the ground, loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity v_0 is
(Take $g = 10$ m s^{-2})
(a) 28 m s^{-1} (b) 10 m s^{-1}
(c) 14 m s^{-1} (d) 20 m s^{-1} *(2015)*

11. On a frictionless surface, a block of mass M moving at speed v collides elastically with another block of same mass M which is initially at rest. After collision the first block moves at an angle θ to its initial direction and has a speed $\frac{v}{3}$. The second block's speed after the collision is
(a) $\frac{3}{\sqrt{2}}v$ (b) $\frac{\sqrt{3}}{2}v$
(c) $\frac{2\sqrt{2}}{3}v$ (d) $\frac{3}{4}v$ *(2015)*

12. A particle of mass m is driven by a machine that delivers a constant power k watts. If the particle starts from rest the force on the particle at time t is
(a) $\sqrt{2mk}\, t^{-1/2}$ (b) $\frac{1}{2}\sqrt{mk}\, t^{-1/2}$
(c) $\sqrt{\frac{mk}{2}}\, t^{-1/2}$ (d) $\sqrt{mk}\, t^{-1/2}$
(2015 Cancelled)

13. A block of mass 10 kg, moving in x direction with a constant speed of 10 m s^{-1}, is subjected to a retarding force $F = 0.1x$ J/m during its travel from $x = 20$ m to 30 m. Its final KE will be
(a) 275 J (b) 250 J (c) 475 J (d) 450 J
(2015 Cancelled)

14. Two particles of masses m_1, m_2 move with initial velocities u_1 and u_2. On collision, one of the particles get excited to higher level, after absorbing energy ε. If final velocities of particles be v_1 and v_2 then we must have
(a) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$
(b) $\frac{1}{2}m_1^2u_1^2 + \frac{1}{2}m_2^2u_2^2 + \varepsilon = \frac{1}{2}m_1^2v_1^2 + \frac{1}{2}m_2^2v_2^2$
(c) $m_1^2u_1 + m_2^2u_2 - \varepsilon = m_1^2v_1 + m_2^2v_2$
(d) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \varepsilon$
(2015 Cancelled)

15. 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) $W_P > W_Q$; $W_Q > W_P$
(b) $W_P < W_Q$; $W_Q < W_P$
(c) $W_P = W_Q$; $W_P > W_Q$
(d) $W_P = W_Q$; $W_P = W_Q$ *(2015 Cancelled)*

16. A body of mass $(4m)$ is lying in x-y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is
(a) mv^2 (b) $\frac{3}{2}mv^2$ (c) $2mv^2$ (d) $4mv^2$
(2014)

17. A uniform force of $(3\hat{i} + \hat{j})$ newton acts on a particle of mass 2 kg. Hence the particle is displaced from position $(2\hat{i} + \hat{k})$ metre to position $(4\hat{i} + 3\hat{j} - \hat{k})$ metre. The work done by the force on the particle is
(a) 13 J (b) 15 J (c) 9 J (d) 6 J
(NEET 2013)

18. A particle with total energy E is moving in a potential energy region $U(x)$. Motion of the particle is restricted to the region when
(a) $U(x) < E$ (b) $U(x) = 0$
(c) $U(x) \le E$ (d) $U(x) > E$
(Karnataka NEET 2013)

19. One coolie takes 1 minute to raise a suitcase through a height of 2 m but the second coolie takes 30 s to raise the same suitcase to the same height. The powers of two coolies are in the ratio
(a) 1 : 3 (b) 2 : 1 (c) 3 : 1 (d) 1 : 2
(Karnataka NEET 2013)

20. The potential energy of a particle in a force field is $U = \frac{A}{r^2} - \frac{B}{r}$ where A and B are positive constants and r is the distance of particle from the centre of the field. For stable equilibrium, the distance of the particle is
(a) $\frac{B}{2A}$ (b) $\frac{2A}{B}$ (c) $\frac{A}{B}$ (d) $\frac{B}{A}$
(2012)

21. A solid cylinder of mass 3 kg is rolling on a horizontal surface with velocity 4 m s^{-1}. It collides with a horizontal spring of force constant 200 N m^{-1}. The maximum compression produced in the spring will be
(a) 0.5 m (b) 0.6 m (c) 0.7 m (d) 0.2 m
(2012)

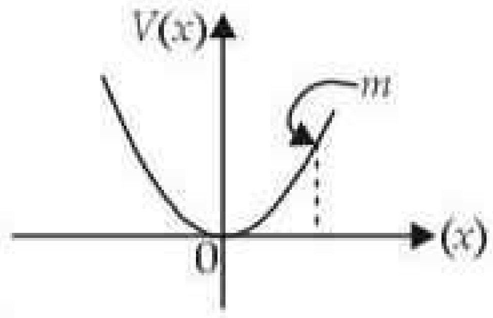
22. Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v along x-axis. After collision B has a velocity in a direction perpendicular to the original direction. The mass A moves after collision in the direction
(a) same as that of B
(b) opposite to that of B
(c) $\theta = \tan^{-1}\left(\frac{1}{2}\right)$ to the x-axis
(d) $\theta = \tan^{-1}\left(-\frac{1}{2}\right)$ to the x-axis *(2012)*

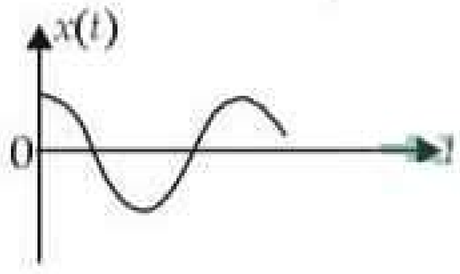
23. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0. The instantaneous velocity of this car is proportional to
(a) t^2P_0 (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$
(Mains 2012)

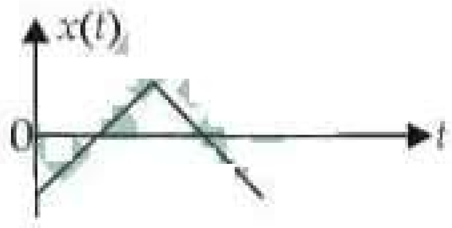
24. The potential energy of a system increases if work is done
(a) upon the system by a nonconservative force.
(b) by the system against a conservative force.
(c) by the system against a nonconservative force.
(d) upon the system by a conservative force.
(2011)

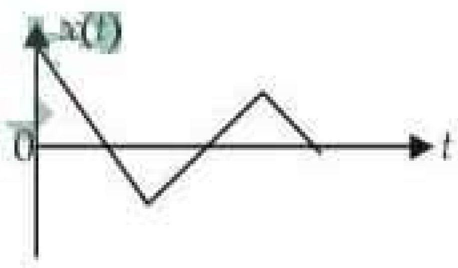
25. A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest
(a) at the highest position of the body.
(b) at the instant just before the body hits the earth.
(c) it remains constant all through.
(d) at the instant just after the body is projected. *(2011)*

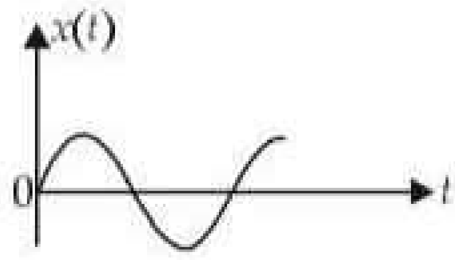
26. A particle of mass m is released from rest and follows a parabolic path as shown. Assuming that the displacement of the mass from the origin is small, which graph correctly depicts the position of the particle as a function of time?



(a) 

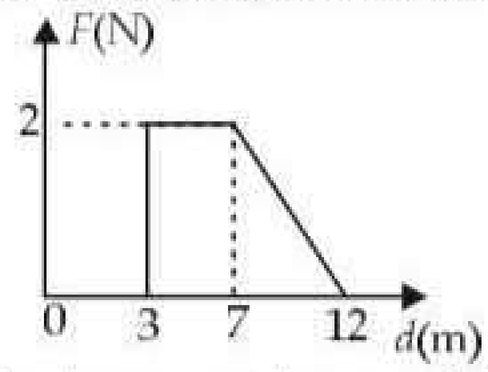
(b) 

(c) 

(d) 

(2011)

27. Force F on a particle moving in a straight line varies with distance d as shown in figure.



The work done on the particle during its displacement of 12 m is
(a) 18 J (b) 21 J (c) 26 J (d) 13 J
(2011)

28. A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to a mass of $3m$ moving vertically upward (along the y-axis) with velocity $2v$. The final velocity of the combination is
(a) $\frac{3}{2}v\hat{i} + \frac{1}{4}v\hat{j}$ (b) $\frac{1}{4}v\hat{i} + \frac{3}{2}v\hat{j}$
(c) $\frac{1}{3}v\hat{i} + \frac{2}{3}v\hat{j}$ (d) $\frac{2}{3}v\hat{i} + \frac{1}{3}v\hat{j}$
(Mains 2011)

29. A ball moving with velocity 2 m/s collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in m/s) after collision will be
(a) 0, 1 (b) 1, 1 (c) 1, 0.5 (d) 0, 2 *(2010)*

30. 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 *(2010)*

31. A particle of mass M, starting from rest, undergoes uniform acceleration. If the speed acquired in time T is V, the power delivered to the particle is
(a) $\frac{MV^2}{T}$ (b) $\frac{1}{2}\frac{MV^2}{T^2}$
(c) $\frac{MV^2}{T^2}$ (d) $\frac{1}{2}\frac{MV^2}{T}$ *(Mains 2010)*

32. A block of mass M is attached to the lower end of a vertical spring. The spring is hung from a ceiling and has force constant value k. The mass is released from rest with the spring initially unstretched. The maximum extension produced in the length of the spring will be
(a) $2Mg/k$ (b) $4Mg/k$
(c) $Mg/2k$ (d) Mg/k *(2009)*

33. A body of mass 1 kg is thrown upwards with a velocity 20 m/s. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction? (g = 10 m/s²)
(a) 30 J (b) 40 J (c) 10 J (d) 20 J *(2009)*

34. An explosion blows a rock into three parts. Two parts go off at right angles to each other. These two are, 1 kg first part moving with a velocity of 12 m s^{-1} and 2 kg second part moving with a velocity 8 m s^{-1}. If the third part flies off with a velocity of 4 m s^{-1}, its mass would be
(a) 7 kg (b) 17 kg (c) 3 kg (d) 5 kg *(2009)*

35. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water jet. What is the rate at which kinetic energy is imparted to water?
(a) mv^3 (b) $\frac{1}{2}mv^2$
(c) $\frac{1}{2}m^2v^2$ (d) $\frac{1}{2}mv^3$ *(2009)*

36. A shell of mass 200 gm is ejected from a gun of mass 4 kg by an explosion that generates 1.05 kJ of energy. The initial velocity of the shell is
(a) 40 ms^{-1} (b) 120 ms^{-1}
(c) 100 ms^{-1} (d) 80 ms^{-1} *(2008)*

37. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine ? (g = 10 m/s²)
(a) 12.3 kW (b) 7.0 kW
(c) 8.1 kW (d) 10.2 kW *(2008)*

38. 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) $mg(h+d)+\frac{1}{2}kd^2$. *(2007)*

39. 300 J of work is done in sliding a 2 kg block up an inclined plane of height 10 m. Work done against friction is (Take g = 10 m/s²)
(a) 1000 J (b) 200 J
(c) 100 J (d) zero. *(2006)*

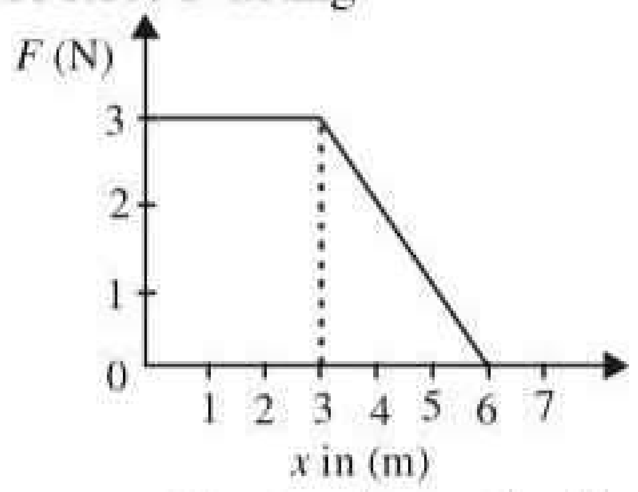
40. The potential energy of a long spring when stretched by 2 cm is U. If the spring is stretched by 8 cm the potential energy stored in it is
(a) $U/4$ (b) $4U$ (c) $8U$ (d) $16U$. *(2006)*

41. A body of mass 3 kg is under a constant force which causes a displacement s in metres in it, given by the relation $s = \frac{1}{3}t^2$, where t is in seconds. Work done by the force in 2 seconds is

(a) $\frac{19}{5}$ J (b) $\frac{5}{19}$ J
(c) $\frac{3}{8}$ J (d) $\frac{8}{3}$ J. *(2006)*

42. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 m s^{-1}. The kinetic energy of the other mass is
(a) 324 J (b) 486 J
(c) 256 J (d) 524 J. *(2005)*

43. A force F acting



on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from $x = 0$ to $x = 6$ m is
(a) 18.0 J (b) 13.5 J
(c) 9.0 J (d) 4.5 J. *(2005)*

44. 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) $\frac{E_1}{E_2} = \frac{m_1}{m_2}$
(c) $E_1 > E_2$ (d) $E_1 = E_2$ *(2004)*

45. A ball of mass 2 kg and another of mass 4 kg are dropped together from a 60 feet tall building. After a fall of 30 feet each towards earth, their respective kinetic energies will be in the ratio of
(a) $\sqrt{2} : 1$ (b) 1 : 4
(c) 1 : 2 (d) $1 : \sqrt{2}$ *(2004)*

46. A mass of 0.5 kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant $k = 50$ N/m. The maximum compression of the spring would be

(a) 0.15 m (b) 0.12 m
(c) 1.5 m (d) 0.5 m *(2004)*

47. When a long spring is stretched by 2 cm, its potential energy is U. If the spring is stretched by 10 cm, the potential energy stored in it will be
(a) $U/5$ (b) $5U$
(c) $10U$ (d) $25U$ *(2003)*

48. A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1/E_2 is
(a) m_2/m_1 (b) m_1/m_2
(c) 1 (d) m_1v_2/m_2v_1
(2003)

49. If kinetic energy of a body is increased by 300% then percentage change in momentum will be
(a) 100% (b) 150%
(c) 265% (d) 73.2%. *(2002)*

50. A child is sitting on a swing. Its minimum and maximum heights from the ground 0.75 m and 2 m respectively, its maximum speed will be
(a) 10 m/s (b) 5 m/s
(c) 8 m/s (d) 15 m/s. *(2001)*

51. Two springs A and B having spring constant K_A and K_B ($K_A = 2K_B$) are stretched by applying force of equal magnitude. If energy stored in spring A is E_A then energy stored in B will be
(a) $2E_A$ (b) $E_A/4$
(c) $E_A/2$ (d) $4E_A$. *(2001)*

52. A particle is projected making an angle of 45° with horizontal having kinetic energy K. The kinetic energy at highest point will be
(a) $\frac{K}{\sqrt{2}}$ (b) $\frac{K}{2}$ (c) $2K$ (d) K.
(2001, 1997)

53. If $\vec{F} = (60\hat{i} + 15\hat{j} - 3\hat{k})$ N and $\vec{v} = (2\hat{i} - 4\hat{j} + 5\hat{k})$ m/s, then instantaneous power is
(a) 195 watt (b) 45 watt
(c) 75 watt (d) 100 watt. *(2000)*

54. A mass of 1 kg is thrown up with a velocity of 100 m/s. After 5 seconds, it explodes into two parts. One part of mass 400 g comes down with a velocity 25 m/s. The velocity of other part is (Take $g = 10$ ms^{-2})
(a) 40 m/s (b) 40 m/s
(c) 100 m/s (d) 60 m/s *(2000)*

55. Two bodies with kinetic energies in the ratio of 4 : 1 are moving with equal linear momentum. The ratio of their masses is
(a) 4 : 1 (b) 1 : 1
(c) 1 : 2 (d) 1 : 4. *(1999)*

56. Two equal masses m_1 and m_2 moving along the same straight line with velocities + 3 m/s and –5 m/s respectively collide elastically. Their velocities after the collision will be respectively
(a) – 4 m/s and +4 m/s
(b) +4 m/s for both
(c) – 3 m/s and +5 m/s
(d) – 5 m/s and + 3 m/s. *(1998)*

57. A force acts on a 3 g 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 second is
(a) 490 mJ (b) 450 mJ
(c) 576 mJ (d) 530 mJ. *(1998)*

58. A shell, in flight, explodes into four unequal parts. Which of the following is conserved?
(a) Potential energy (b) Momentum
(c) Kinetic energy (d) Both (a) and (c). *(1998)*

59. Two bodies of masses m and $4m$ are moving with equal kinetic energies. The ratio of their linear momenta is
(a) 1 : 2 (b) 1 : 4 (c) 4 : 1 (d) 1 : 1. *(1998, 1997, 1989)*

60. A metal ball of mass 2 kg moving with speed of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after collision, both the balls move as a single mass, then the loss in K.E. due to collision is
(a) 100 J (b) 140 J
(c) 40 J (d) 60 J. *(1997)*

61. A body moves a distance of 10 m along a straight line under the action of a 5 N force. If the work done is 25 J, then angle between the force and direction of motion of the body is
(a) 60° (b) 75°
(c) 30° (d) 45°. *(1997)*

62. A moving body of mass m and velocity 3 km/hour collides with a rest body of mass $2m$ and sticks to it. Now the combined mass starts to move. What will be the combined velocity?
(a) 3 km/hour (b) 4 km/hour
(c) 1 km/hour (d) 2 km/hour. *(1996)*

63. The potential energy between two atoms, in a molecule, is given by $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$ where a and b are positive constants and x is the distance between the atoms. The atom is in stable equilibrium, when
(a) $x = \left(\frac{2a}{b}\right)^{1/6}$ (b) $x = \left(\frac{11a}{5b}\right)^{1/6}$
(c) $x = 0$ (d) $x = \left(\frac{a}{2b}\right)^{1/6}$. *(1995)*

64. A body, constrained to move in y-direction, is subjected to a force given by $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})$ N The work done by this force in moving the body through a distance of $10\hat{j}$ m along y-axis, is
(a) 150 J (b) 20 J
(c) 190 J (d) 160 J. *(1994)*

65. The kinetic energy acquired by a mass m in travelling distance d, starting from rest, under the action of a constant force is directly proportional to
(a) m (b) m^0
(c) $\sqrt{m}$ (d) $1/\sqrt{m}$. *(1994)*

66. A position dependent force, $F = (7 - 2x + 3x^2)$ N acts on a small body of mass 2 kg and displaces it from $x = 0$ to $x = 5$ m. The work done in joule is
(a) 135 (b) 270
(c) 35 (d) 70. *(1994, 1992)*

67. When a body moves with a constant speed along a circle
(a) no work is done on it
(b) no acceleration is produced in it
(c) its velocity remains constant
(d) no force acts on it. *(1994)*

68. Two masses of 1 g and 9 g are moving with equal kinetic energies. The ratio of the magnitudes of their respective linear momenta is
(a) 1 : 9 (b) 9 : 1
(c) 1 : 3 (d) 3 : 1 *(1993)*

69. A particle of mass M is moving in a horizontal circle of radius R with uniform speed v. When it moves from one point to a diametrically opposite point, its

(a) kinetic energy change by $Mv^2/4$
(b) momentum does not change
(c) momentum change by $2Mv$
(d) kinetic energy changes by Mv^2 *(1992)*

70. How much water a pump of 2 kW can raise in one minute to a height of 10 m ? (take $g = 10$ m/s^2)
(a) 1000 litres
(b) 1200 litres
(c) 100 litres
(d) 2000 litres *(1990)*

71. A bullet of mass 10 g leaves a rifle at an initial velocity of 1000 m/s and strikes the earth at the same level with a velocity of 500 m/s. The work done in joule overcoming the resistance of air will be
(a) 375 (b) 3750
(c) 5000 (d) 500 *(1989)*

72. The coefficient of restitution e for a perfectly elastic collision is
(a) 1 (b) 0
(c) ∞ (d) –1 *(1988)*

Answer Key

1.	(c)	**2.**	(c)	**3.**	(b)	**4.**	(c)	**5.**	(c)	**6.**	(b)	**7.**	(b)	**8.**	(c)	**9.**	(c)	**10.**	(d)
11.	(c)	**12.**	(c)	**13.**	(c)	**14.**	(a)	**15.**	(a)	**16.**	(b)	**17.**	(c)	**18.**	(c)	**19.**	(d)	**20.**	(b)
21.	(b)	**22.**	(d)	**23.**	(b)	**24.**	(b)	**25.**	(b)	**26.**	(a)	**27.**	(d)	**28.**	(b)	**29.**	(a)	**30.**	(d)
31.	(d)	**32.**	(a)	**33.**	(d)	**34.**	(d)	**35.**	(d)	**36.**	(c)	**37.**	(c)	**38.**	(a)	**39.**	(c)	**40.**	(d)
41.	(d)	**42.**	(b)	**43.**	(b)	**44.**	(a)	**45.**	(c)	**46.**	(a)	**47.**	(d)	**48.**	(a)	**49.**	(a)	**50.**	(b)
51.	(a)	**52.**	(b)	**53.**	(b)	**54.**	(c)	**55.**	(d)	**56.**	(d)	**57.**	(c)	**58.**	(b)	**59.**	(a)	**60.**	(d)
61.	(a)	**62.**	(c)	**63.**	(a)	**64.**	(a)	**65.**	(b)	**66.**	(a)	**67.**	(a)	**68.**	(c)	**69.**	(c)	**70.**	(b)
71.	(b)	**72.**	(a)																

EXPLANATIONS

1. **(c) :** Here, $m = 1\text{ g} = 10^{-3}\text{ kg}$, $h = 1\text{ km} = 1000\text{ m}$, $v = 50\text{ m s}^{-1}$, $g = 10\text{ m s}^{-2}$.

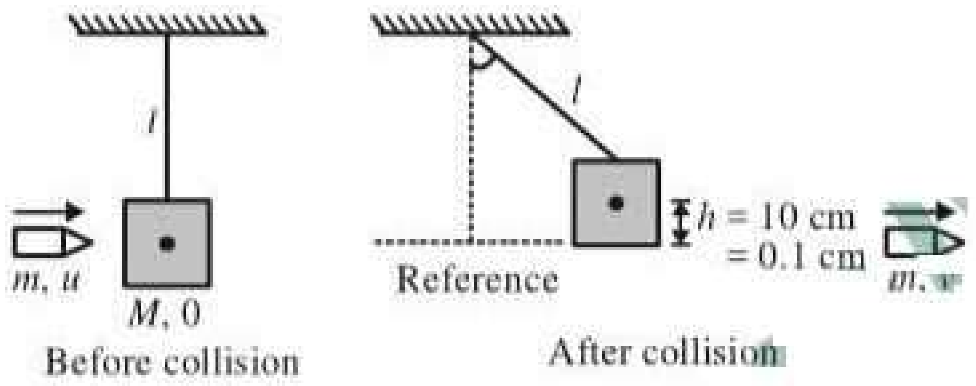
(i) The work done by the gravitational force
$= mgh = 10^{-3} \times 10 \times 1000 = 10\text{ J}$

(ii) The total work done by gravitational force and the resistive force of air is equal to change in kinetic energy of rain drop.

$$\therefore \quad W_g + W_r = \frac{1}{2}mv^2 - 0$$

$$10 + W_r = \frac{1}{2} \times 10^{-3} \times 50 \times 50 \text{ or } W_r = -8.75\text{ J}$$

2. **(c) :** Mass of bullet, $m = 10\text{ g} = 0.01\text{ kg}$
Initial speed of bullet, $u = 400\text{ m s}^{-1}$
Mass of block, $M = 2\text{ kg}$
Length of string, $l = 5\text{ m}$
Speed of the block after collision $= v_1$
Speed of the bullet on emerging from block, $v = ?$



Using energy conservation principle for the block,
$(KE + PE)_{\text{Reference}} = (KE + PE)_h$

$$\Rightarrow \frac{1}{2}Mv_1^2 = Mgh \text{ or, } v_1 = \sqrt{2gh}$$

$$v_1 = \sqrt{2 \times 10 \times 0.1} = \sqrt{2}\text{ m s}^{-1}$$

Using momentum conservation principle for block and bullet system,
$(M \times 0 + mu)_{\text{Before collision}} = (M \times v_1 + mv)_{\text{After collision}}$

$$\Rightarrow 0.01 \times 400 = 2\sqrt{2} + 0.01 \times v$$

$$\Rightarrow v = \frac{4 - 2\sqrt{2}}{0.01} = 117.15\text{ m s}^{-1} \approx 120\text{ m s}^{-1}$$

3. **(b) :** Masses of the balls are same and collision is elastic, so their velocity will be interchanged after collision.

4. **(c) :** Here $\vec{r}_1 = (-2\hat{i} + 5\hat{j})\text{m}$, $\vec{r}_2 = (4\hat{j} + 3\hat{k})\text{m}$
$\vec{F} = (4\hat{i} + 3\hat{j})\text{N}$, W = ?
Work done by force F in moving from $\vec{r}_1$ to $\vec{r}_2$,

$$W = \vec{F} \cdot (\vec{r}_2 - \vec{r}_1) \Rightarrow W = (4\hat{i} + 3\hat{j}) \cdot (4\hat{j} + 3\hat{k} + 2\hat{i} - 5\hat{j})$$

$$= (4\hat{i} + 3\hat{j}) \cdot (2\hat{i} - \hat{j} + 3\hat{k}) = 8 + (-3) = 5\text{ J}$$

5. **(c) :** Here, $m = 10\text{ g} = 10^{-2}\text{ kg}$,
$R = 6.4\text{ cm} = 6.4 \times 10^{-2}\text{m}$, $K_f = 8 \times 10^{-4}\text{ J}$, $K_i = 0$, $a_t = ?$
Using work energy theorem,
Work done by all the forces = Change in KE
$W_{\text{tangential force}} + W_{\text{centripetal force}} = K_f - K_i$

$$\Rightarrow a_t = \frac{K_f}{4\pi Rm} = \frac{8 \times 10^{-4}}{4 \times \frac{22}{7} \times 6.4 \times 10^{-2} \times 10^{-2}}$$

$$= 0.099 \approx 0.1\text{ m s}^{-2}$$

6. **(b) :** Here, $\vec{F} = (2t\hat{i} + 3t^2\hat{j})\text{ N}$, $m = 1\text{ kg}$

Acceleration of the body, $\vec{a} = \frac{\vec{F}}{m} = \frac{(2t\hat{i} + 3t^2\hat{j})\text{ N}}{1\text{kg}}$

Velocity of the body at time t,

$$\vec{v} = \int \vec{a}dt = \int (2t\hat{i} + 3t^2\hat{j})dt = t^2\hat{i} + t^3\hat{j}\text{ m s}^{-1}$$

$\therefore$ Power developed by the force at time t,

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

7. **(b)**

8. **(c) :** Let the particles A and B collide at time t. For their collision, the position vectors of both particles should be same at time t, *i.e.*,

$$\vec{r}_1 + \vec{v}_1 t = \vec{r}_2 + \vec{v}_2 t\ ;\ \vec{r}_1 - \vec{r}_2 = \vec{v}_2 t - \vec{v}_1 t = (\vec{v}_2 - \vec{v}_1)t \quad \text{...(i)}$$

Also, $|\vec{r}_1 - \vec{r}_2| = |\vec{v}_2 - \vec{v}_1|t$ or $t = \frac{|\vec{r}_1 - \vec{r}_2|}{|\vec{v}_2 - \vec{v}_1|}$

Substituting this value of t in eqn. (i), we get

$$\vec{r}_1 - \vec{r}_2 = (\vec{v}_2 - \vec{v}_1)\frac{|\vec{r}_1 - \vec{r}_2|}{|\vec{v}_2 - \vec{v}_1|}$$

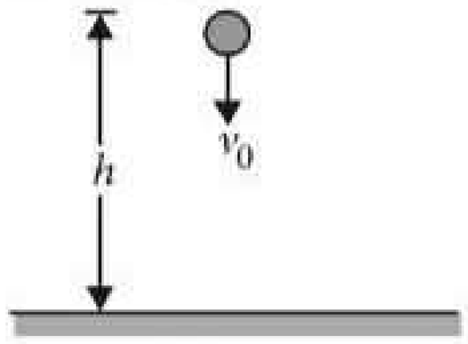
$$\text{or} \quad \frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|} = \frac{(\vec{v}_2 - \vec{v}_1)}{|\vec{v}_2 - \vec{v}_1|}$$

9. **(c) :** Here, Volume of blood pumped by man's heart,
$V = 5\text{ litres} = 5 \times 10^{-3}\text{ m}^3$ ($\because$ 1 litre $= 10^{-3}\text{ m}^3$)
Time in which this volume of blood pumps,
$t = 1\text{ min} = 60\text{ s}$
Pressure at which the blood pumps,
$P = 150\text{ mm of Hg} = 0.15\text{ m of Hg}$
$= (0.15\text{ m})(13.6 \times 10^3\text{ kg/m}^3)(10\text{ m/s}^2)$ ($\because P = h\rho g$)
$= 20.4 \times 10^3\text{ N/m}^2$

$\therefore$ Power of the heart $= \frac{PV}{t}$

$$= \frac{(20.4 \times 10^3\text{ N/m}^2)(5 \times 10^{-3}\text{m}^3)}{60\text{ s}} = 1.70\text{ W}$$

10. (d) : The situation is shown in the figure. Let v be the velocity of the ball with which it collides with ground. Then according to the law of conservation of energy,



Gain in kinetic energy = loss in potential energy

i.e. $\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = mgh$

(where m is the mass of the ball)

or $v^2 - v_0^2 = 2gh$ ... (i)

Now, when the ball collides with the ground, 50% of its energy is lost and it rebounds to the same height h.

$$\therefore \frac{50}{100}\left(\frac{1}{2}mv^2\right) = mgh$$

$\frac{1}{4}v^2 = gh$ or $v^2 = 4gh$

Substituting this value of v^2 in eqn. (i), we get

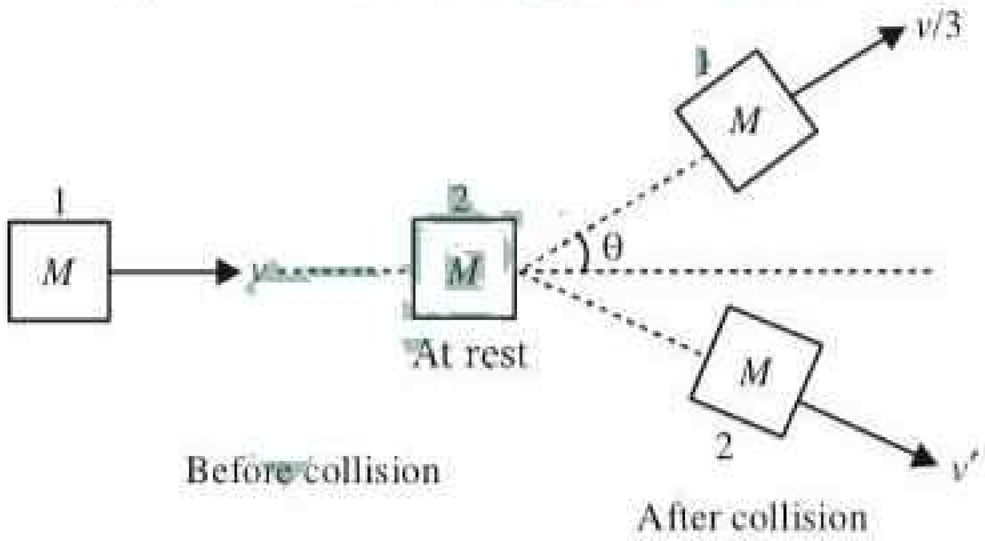
$$4gh - v_0^2 = 2gh$$

or $v_0^2 = 4gh - 2gh = 2gh$ or $v_0 = \sqrt{2gh}$

Here, $g = 10$ ms^{-2} and $h = 20$ m

$$\therefore v_0 = \sqrt{2(10 \text{ ms}^{-2})(20\text{ m})} = 20 \text{ ms}^{-1}$$

11. (c) : The situation is shown in the figure.



Let v' be speed of second block after the collision. As the collision is elastic, so kinetic energy is conserved.

According to conservation of kinetic energy,

$$\frac{1}{2}Mv^2 + 0 = \frac{1}{2}M\left(\frac{v}{3}\right)^2 + \frac{1}{2}Mv'^2$$

$$v^2 = \frac{v^2}{9} + v'^2 \text{ or } v'^2 = v^2 - \frac{v^2}{9} = \frac{9v^2 - v^2}{9} = \frac{8}{9}v^2$$

$$v' = \sqrt{\frac{8}{9}v^2} = \frac{\sqrt{8}}{3}v = \frac{2\sqrt{2}}{3}v$$

12. (c) : Constant power acting on the particle of mass m is k watt.

or $P = k$

$$\frac{dW}{dt} = k; \quad dW = kdt$$

Integrating both sides, $\int_0^W dW = \int_0^t k\,dt$

$\Rightarrow W = kt$ ... (i)

Using work energy theorem, $W = \frac{1}{2}mv^2 - \frac{1}{2}m(0)^2$

$kt = \frac{1}{2}mv^2$ [Using equation (i)]

$$v = \sqrt{\frac{2kt}{m}}$$

Acceleration of the particle, $a = \frac{dv}{dt}$

$$a = \frac{1}{2}\sqrt{\frac{2k}{m}}\frac{1}{\sqrt{t}} = \sqrt{\frac{k}{2mt}}$$

Force on the particle, $F = ma = \sqrt{\frac{mk}{2t}} = \sqrt{\frac{mk}{2}}\,t^{-1/2}$

13. (c) : Here, $m = 10$ kg, $v_i = 10$ m s^{-1}

Initial kinetic energy of the block is

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}\times(10\text{ kg})\times(10\text{ m s}^{-1})^2 = 500\text{ J}$$

Work done by retarding force

$$W = \int_{x_1}^{x_2} F_r dx = \int_{20}^{30} -0.1\,x dx = -0.1\left[\frac{x^2}{2}\right]_{20}^{30}$$

$$= -0.1\left[\frac{900-400}{2}\right] = -25\text{ J}$$

According to work-energy theorem,

$W = K_f - K_i$

$K_f = W + K_i = -25\text{ J} + 500\text{ J} = 475\text{ J}$

14. (a) : Total initial energy of two particles

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

Total final energy of two particles

$$= \frac{1}{2}m_2v_2^2 + \frac{1}{2}m_1v_1^2 + \varepsilon$$

Using energy conservation principle,

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon$$

$$\therefore \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

15. **(a) :** Here, $K_P > K_Q$

Case (a) : Elongation (x) in each spring is same.

$$W_P = \frac{1}{2}K_P x^2,\ W_Q = \frac{1}{2}K_Q x^2$$

$\therefore \quad W_P > W_Q$

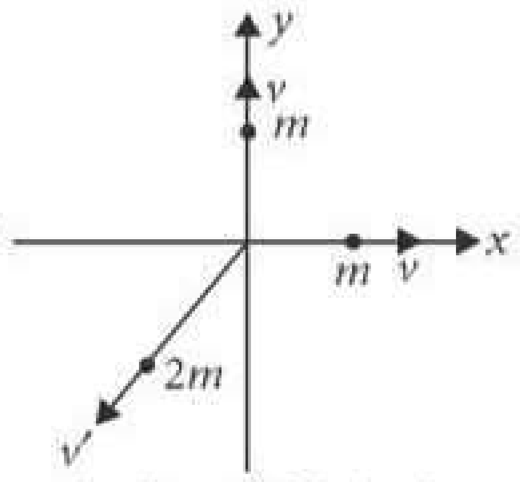
Case (b) : Force of elongation is same.

So, $x_1 = \dfrac{F}{K_P}$ and $x_2 = \dfrac{F}{K_Q}$

$$W_P = \frac{1}{2}K_P x_1^2 = \frac{1}{2}\frac{F^2}{K_P}$$

$$W_Q = \frac{1}{2}K_Q x_2^2 = \frac{1}{2}\frac{F^2}{K_Q} \qquad \therefore\ W_P < W_Q$$

16. **(b) :**



Let $\vec{v}'$ be velocity of third piece of mass $2m$

Initial momentum, $\vec{p}_i = 0$ (As the body is at rest)

Final momentum, $\vec{p}_f = mv\hat{i} + mv\hat{j} + 2m\vec{v}'$

According to law of conservation of momentum

$$\vec{p}_i = \vec{p}_f$$

$$0 = mv\hat{i} + mv\hat{j} + 2m\vec{v}'$$

$$\vec{v}' = -\frac{v}{2}\hat{i} - \frac{v}{2}\hat{j}$$

The magnitude of v' is

$$v' = \sqrt{\left(-\frac{v}{2}\right)^2 + \left(-\frac{v}{2}\right)^2} = \frac{v}{\sqrt{2}}$$

Total kinetic energy generated due to explosion

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v'^2$$

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

$$= mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$$

17. **(c) :** Here, $\vec{F} = (3\hat{i} + \hat{j})$ N

Initial position, $\vec{r}_1 = (2\hat{i} + \hat{k})$ m

Final position, $\vec{r}_2 = (4\hat{i} + 3\hat{j} - \hat{k})$ m

Displacement, $\vec{r} = \vec{r}_2 - \vec{r}_1$

$$\vec{r} = (4\hat{i} + 3\hat{j} - \hat{k})\text{ m} - (2\hat{i} + \hat{k})\text{ m} = 2\hat{i} + 3\hat{j} - 2\hat{k}\text{ m}$$

Work done,

$$W = \vec{F}\cdot\vec{r} = (3\hat{i} + \hat{j})\cdot(2\hat{i} + 3\hat{j} - 2\hat{k}) = 6 + 3 = 9\text{ J}$$

18. **(c)**

19. **(d) :** Power, $P = \dfrac{\text{Work done}}{\text{Time taken}}$

Here work done ($= mgh$) is same in both cases.

$$\therefore \quad \frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{30\text{ s}}{1\text{ min}} = \frac{30\text{ s}}{60\text{ s}} = \frac{1}{2}$$

20. **(b) :** Here, $U = \dfrac{A}{r^2} - \dfrac{B}{r}$

For equilibrium, $\dfrac{dU}{dr} = 0$

$$\therefore \quad -\frac{2A}{r^3} + \frac{B}{r^2} = 0 \text{ or } \frac{2A}{r^3} = \frac{B}{r^2} \text{ or } r = \frac{2A}{B}$$

For stable equilibrium, $\dfrac{d^2U}{dr^2} > 0$

$$\frac{d^2U}{dr^2} = \frac{6A}{r^4} - \frac{2B}{r^3}$$

$$\left.\frac{d^2U}{dr^2}\right|_{r=(2A/B)} = \frac{6AB^4}{16A^4} - \frac{2B^4}{8A^3} = \frac{B^4}{8A^3} > 0$$

So for stable equilibrium, the distance of the particle is $\dfrac{2A}{B}$.

21. **(b) :** At maximum compression the solid cylinder will stop.

According to law of conservation of mechanical energy

Loss in kinetic energy = Gain in potential energy of cylinder of spring

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}kx^2$$

$$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{mR^2}{2}\right)\left(\frac{v}{R}\right)^2 = \frac{1}{2}kx^2z$$

($\because$ $v = R\omega$ and for solid cylinder, $I = \frac{1}{2}mR^2$)

$$\frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{1}{2}kx^2$$

$$\frac{3}{4}mv^2 = \frac{1}{2}kx^2 \text{ or } x^2 = \frac{3}{2}\frac{mv^2}{k}$$

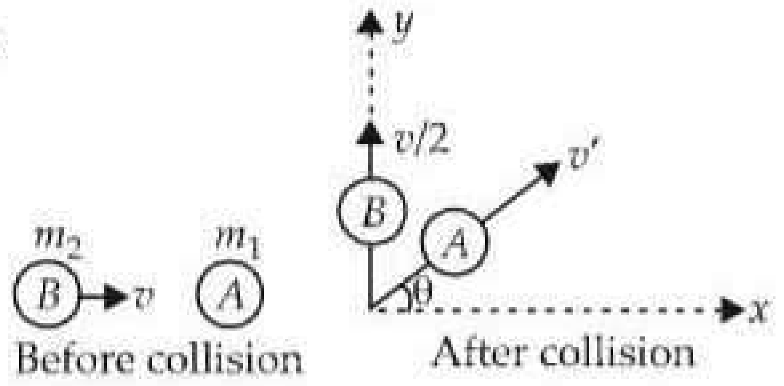
Here, $m = 3$ kg, $v = 4$ m s^{-1}, $k = 200$ N m^{-1}

Substituting the given values, we get

$$x^2 = \frac{3\times 3\times 4\times 4}{2\times 200}$$

$$x^2 = \frac{36}{100} \text{ or } x = 0.6\text{ m}$$

22. **(d) :**



According to law of conservation of linear momentum along x-axis, we get

$m_1 \times 0 + m_2 \times v = m_1 v' \cos\theta$

$m_2 v = m_1 v' \cos\theta$

or $\cos\theta = \dfrac{m_2 v}{m_1 v'}$ ...(i)

According to law of conservation of linear momentum along y-axis, we get

$$m_1 \times 0 + m_2 \times 0 = m_1 v' \sin\theta + m_2 \frac{v}{2}$$

$$-m_2 \frac{v}{2} = m_1 v' \sin\theta$$

$\sin\theta = -\dfrac{m_2 v}{2 m_1 v'}$ ...(ii)

Divide (ii) by (i), we get

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

23. **(b) :** $P_0 = Fv$

$\because \quad F = ma = m\dfrac{dv}{dt}$

$\therefore \quad P_0 = mv\dfrac{dv}{dt}$ or $P_0 dt = mvdv$

Integrating both sides, we get $\int_0^t P_0 dt = m\int_0^v v dv$

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

$v = \left(\dfrac{2P_0 t}{m}\right)^{1/2}$ or $v \propto \sqrt{t}$

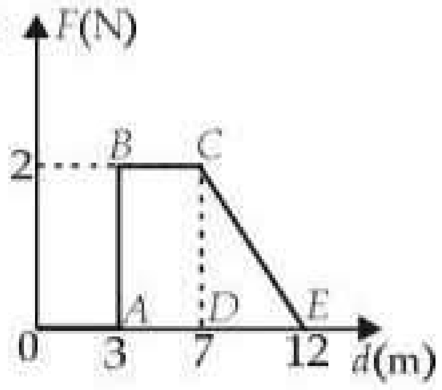
24. **(b)**

25. **(b) :** Power, $P = \vec{F}\cdot\vec{v} = Fv\cos\theta$

Just before hitting the earth $\theta = 0°$. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

26. **(a)**

27. **(d) :**

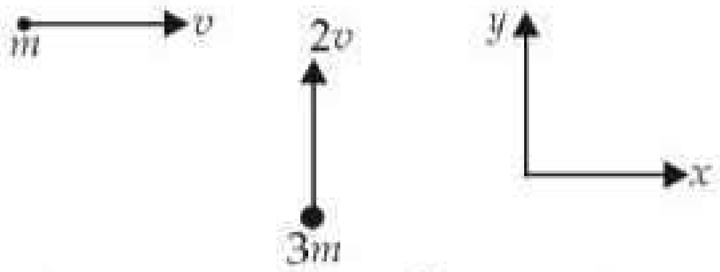


Work done = Area under (F-d) graph

= Area of rectangle $ABCD$ + Area of triangle DCE

$$= 2 \times (7-3) + \frac{1}{2} \times 2 \times (12-7) = 8 + 5 = 13 \text{ J}$$

28. **(b) :**



According to conservation of momentum, we get

$$mv\hat{i} + (3m)2v\hat{j} = (m+3m)\vec{v'}$$

where $\vec{v'}$ is the final velocity after collision

$$\vec{v'} = \frac{1}{4}v\hat{i} + \frac{6}{4}v\hat{j} = \frac{1}{4}v\hat{i} + \frac{3}{2}v\hat{j}$$

29. **(a) :** Here, $m_1 = m$, $m_2 = 2m$

$u_1 = 2$ m/s, $u_2 = 0$

Coefficient of restitution, $e = 0.5$

Let v_1 and v_2 be their respective velocities after collision.

Applying the law of conservation of linear momentum, we get

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore \quad m \times 2 + 2m \times 0 = m \times v_1 + 2m \times v_2$

or $\quad 2m = mv_1 + 2mv_2$

or $\quad 2 = (v_1 + 2v_2)$ ...(i)

By definition of coefficient of restitution,

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

or $\quad e(u_1 - u_2) = v_2 - v_1 \Rightarrow 0.5(2-0) = v_2 - v_1$ ...(ii)

$1 = v_2 - v_1$

Solving equations (i) and (ii), we get

$v_1 = 0$ m/s, $v_2 = 1$ m/s

30. **(d) :** Here,

Mass per unit length of water, $\mu = 100$ kg/m

Velocity of water, $v = 2$ m/s

Power of the engine, $P = \mu v^3 = (100 \text{ kg/m})(2 \text{ m/s})^3$
$= 800$ W

31. **(d) :** Power delivered in time T is

$P = F \cdot V = MaV$

or $P = MV\dfrac{dV}{dT} \Rightarrow PdT = MVdV$

$\Rightarrow PT = \dfrac{MV^2}{2}$ or $P = \dfrac{1}{2}\dfrac{MV^2}{T}$

32. **(a) :** When the mass attached to a spring fixed at the other end is allowed to fall suddenly, it extends the spring by x. Potential energy lost by the mass is gained by the spring.

$$Mgx = \frac{1}{2}kx^2 \Rightarrow x = \frac{2Mg}{k}.$$

33. (d) : Initial velocity $u = 20$ m/s; $m = 1$ kg

Kinetic energy = maximum potential energy

Initial kinetic energy = $\frac{1}{2}\times 1\times 20^2 = 200$ J

Mgh (max) = 200 J.

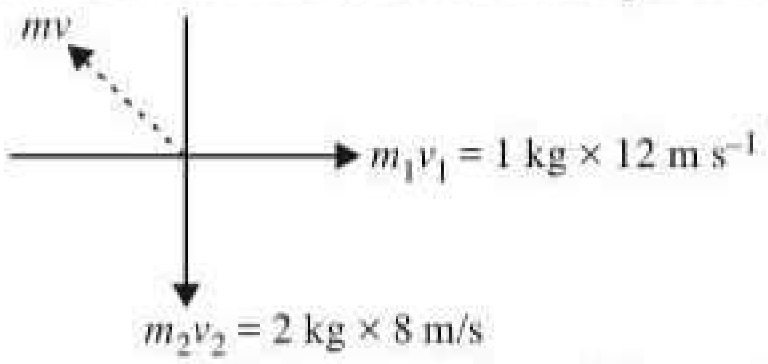
$\therefore$ $h = 20$ m.

The height travelled by the body, $h' = 18$ m

$\therefore$ Loss of energy due to air friction = $mgh - mgh'$

$\Rightarrow$ Energy lost = 200 J – 1 × 10 × 18 J = 20 J.

34. (d) : When an explosion breaks a rock, by the law of conservation of momentum, initial momentum is zero and for the three pieces,



Total momentum of the two pieces 1 kg and 2 kg

$= \sqrt{12^2 + 16^2} = 20$ kg ms^{-1}.

The third piece has the same momentum and in the direction opposite to the resultant of these two momenta.

$\therefore$ Momentum of the third piece = 20 kg ms^{-1}

Velocity = 4 ms^{-1}

$\therefore$ Mass of the 3rd piece = $\frac{mv}{v} = \frac{20}{4} = 5$ kg

35. (d) : Velocity of water is v, mass flowing per unit length is m.

$\therefore$ Mass flowing per second = mv

$\therefore$ Rate of kinetic energy or K.E. per second

$= \frac{1}{2}(mv)v^2 = \frac{1}{2}mv^3$.

36. (c) : $mv = Mv' \Rightarrow v' = \left(\frac{m}{M}\right)v$

Total K.E. of the bullet and gun

$= \frac{1}{2}mv^2 + \frac{1}{2}Mv'^2$

Total K.E = $\frac{1}{2}mv^2 + \frac{1}{2}M\cdot\frac{m^2}{M^2}v^2$

Total K.E. = $\frac{1}{2}mv^2\left\{1 + \frac{m}{M}\right\}$

$= \left\{\frac{1}{2}\times 0.2\right\}\left\{1 + \frac{0.2}{4}\right\}v^2 = 1.05\times 1000$ J

$\Rightarrow v^2 = \frac{4\times 1.05\times 1000}{0.1\times 4.2} = 100^2$;

$\therefore$ $v = 100$ ms^{-1}

37. (c) : Mass of water falling/second = 15 kg/s

$h = 60$ m, $g = 10$ m/s^2, loss = 10% *i.e.*, 90% is used.

Power generated = 15 × 10 × 60 × 0.9 = 8100 W = 8.1 kW.

38. (a) : When a mass falls on a spring from a height h the work done by the loss of granitational potential energy of the mass is stored as the potential energy of the spring.

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

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

The two energies are equal.

If work done is initial P.E. – final P.E., it is zero. Work done is totally converted (assuming there is no loss). The work done in compression or expansion is always positive as it is $\propto x^2$. The answer expected is

$mg(h+d) - \frac{1}{2}kd^2$ or, $\frac{1}{2}kd^2 - mg(h+d)$ as seen from options, but it is not justified.

Question could have been more specific like work done by oscillation.

39. (c) : Loss in potential energy = mgh

= 2 × 10 × 10 = 200 J.

Gain in kinetic energy = work done = 300 J

$\therefore$ Work done against friction = 300 – 200 = 100 J

40. (d) : Potential energy of a spring

$= \frac{1}{2}\times$ force constant $\times$ (extension)^2

$\therefore$ Potential energy $\propto$ (extension)^2.

or, $\frac{U_1}{U_2} = \left(\frac{x_1}{x_2}\right)^2$ or, $\frac{U_1}{U_2} = \left(\frac{2}{8}\right)^2$

or, $\frac{U_1}{U_2} = \frac{1}{16}$ or, $U_2 = 16U_1 = 16U$. $(\because U_1 = U)$

41. (d) : $s = \frac{t^2}{3}$; $\frac{ds}{dt} = \frac{2t}{3}$; $\frac{d^2s}{dt^2} = \frac{2}{3}$

Work done, $W = \int F ds = \int m\frac{d^2s}{dt^2}ds$

$= \int m\frac{d^2s}{dt^2}\frac{ds}{dt}dt = \int_0^2 3\times\frac{2}{3}\times\frac{2t}{3}dt = \frac{4}{3}\int_0^2 t\,dt$

$= \frac{4}{3}\int_0^2 t\,dt = \frac{4}{3}\left|\frac{t^2}{2}\right|_0^2 = \frac{4}{3}\times 2 = \frac{8}{3}$ J.

42. (b) : According to law of conservation of angular momentum,

$30 \times 0 = 18 \times 6 + 12 \times v$

$\Rightarrow \quad 108 = 12v \;\Rightarrow\; v = -9$ m/s.

Negative sign indicates that both fragments move in opposite direction.

K.E. of 12 kg $= \frac{1}{2}mv^2 = \frac{1}{2}\times 12\times 81 = 486$ J.

43. (b) : Work done = area under F-x curve

$= \text{area of trapezium} = \frac{1}{2}\times(6+3)\times 3 = \frac{9\times 3}{2} = 13.5$ J.

44. (a) : Kinetic energy $= \frac{p^2}{2m}$

$\therefore \frac{E_1}{E_2} = \frac{p_1^2/2m_1}{p_2^2/2m_2} \Rightarrow \frac{E_1}{E_2} = \frac{m_2}{m_1}$ as $m_1 > m_2$

$\therefore E_1 < E_2$.

45. (c) : Ratio of their kinetic energy is given as

$\frac{KE_1}{KE_2} = \frac{(1/2)\,m_1v_1^2}{(1/2)\,m_2v_2^2}$

$\Rightarrow \quad v^2 = 2gs$ (zero initial velocity)

which is same for both

$\therefore \quad \frac{KE_1}{KE_2} = \frac{m_1}{m_2} = \frac{2}{4} = \frac{1}{2}$.

46. (a) : The kinetic energy of mass is converted into energy required to compress a spring which is given by

$\Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$\Rightarrow x = \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{0.5\times(1.5)^2}{50}} = 0.15$ m.

47. (d) : $U = -kx^2$, k = Spring constant

$\frac{U_1}{U_2} = \frac{x_1^2}{x_2^2} = \frac{4}{100} \Rightarrow U_2 = 25\,U_1$

48. (a) : $m_1v_1 = m_2v_2$ (conservation of linear momentum)

$\frac{E_1}{E_2} = \frac{(1/2)m_1v_1^2}{(1/2)m_2v_2^2} = \frac{m_1^2v_1^2}{m_2^2v_2^2}\cdot\frac{m_2}{m_1} = \frac{m_2}{m_1}$.

49. (a) : Let m be the mass of the body and v_1 and v_2 be the initial and final velocities of the body respectively.

$\therefore$ Initial kinetic energy $= \frac{1}{2}mv_1^2$

Final kinetic energy $= \frac{1}{2}mv_2^2$

Initial kinetic energy is increased 300% to get the final kinetic energy.

$\therefore \quad \frac{1}{2}mv_2^2 = \frac{1}{2}\left(1+\frac{300}{100}\right)mv_1^2$

$\Rightarrow \quad v_2 = 2v_1$ or $v_2/v_1 = 2$ ... (i)

Initial momentum $= p_1 = mv_1$

Final momentum $= p_2 = mv_2$

$\therefore \quad \frac{p_2}{p_1} = \frac{mv_2}{mv_1} = \frac{v_2}{v_1} = 2$;

$\therefore \quad p_2 = 2p_1 = \left(1+\frac{100}{100}\right)p_1$

So momentum has increased 100%.

50. (b) : Drop in P.E = maximum K.E.

$mg\,(2-0.75) = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2g(1.25)} = 5$ m/s.

51. (a) : Energy $= \frac{1}{2}Kx^2 = \frac{1}{2}\frac{F^2}{K}$.

$\frac{K_A}{K_B} = 2$

$\therefore \quad \frac{E_A}{E_B} = \frac{1}{2}$, or $E_B = 2E_A$.

52. (b) : Kinetic energy of the ball = K and angle of projection (θ) = 45°.

Velocity of the ball at the highest point = $v\cos\theta$

$= v\cos 45^\circ = \frac{v}{\sqrt{2}}$.

Therefore kinetic energy of the ball

$= \frac{1}{2}m\times\left(\frac{v}{\sqrt{2}}\right)^2 = \frac{1}{4}mv^2 = \frac{K}{2}$.

53. (b) : $P = \vec{F}\cdot\vec{v} = (60\hat{i}+15\hat{j}-3\hat{k})\cdot(2\hat{i}-4\hat{j}+5\hat{k})$

$= 120 - 60 - 15 = 45$ watts.

54. (c) : Velocity after 5 sec, $v = u - gt$

$= 100 - 10 \times 5 = 50$ m/s

By conservation of momentum

$1 \times 50 = 0.4 \times (-25) + 0.6 \times v'$

$60 = 0.6 \times v' \Rightarrow v' = 100$ m/s upwards

55. (d) : $\text{K.E.} = \frac{p^2}{2m} \Rightarrow \frac{\text{K.E.}_1}{\text{K.E.}_2} = \frac{m_2}{m_1} = \frac{4}{1}$

or $\quad \frac{m_1}{m_2} = \frac{1}{4}$

56. (d) : Equal masses after elastic collision interchange their velocities.

–5 m/s and +3 m/s.

57. (c) : $x = 3t - 4t^2 + t^3$ or, $\frac{d^2x}{dt^2} = -8 + 6t$

or $\left.\frac{d^2x}{dt^2}\right|_{t=4} = 16$ or $x|_{t=4} = 12$

Work done $= F\cdot s = mas = 3\times 10^{-3}\times 16\times 12 = 576$ mJ.

58. (b)

59. (a) : Mass of first body = m;
Mass of second body = $4m$ and $KE_1 = KE_2$.
Linear momentum of a body

$p = \sqrt{2mE} \propto \sqrt{m}$.

Therefore $\frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{m}{4m}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

or $p_1 : p_2 = 1 : 2$.

60. (d) : Mass of metal ball = 2 kg;
Speed of metal ball (v_1) = 36 km/h = 10 m/s and mass of stationary ball = 3 kg.
Applying law of conservation of momentum,
$m_1v_1 + m_2v_2 = (m_1 + m_2)v$

or, $v = \frac{m_1v_1 + m_2v_2}{m_1 + m_2} = \frac{(2\times10)+(3\times0)}{2+3} = \frac{20}{5} = 4$ m/s.

Therefore loss of energy

$= \left[\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right] - \frac{1}{2}\times(m_1+m_2)v^2$

$= \left[\frac{1}{2}\times2\times(10)^2 + \frac{1}{2}\times3(0)^2\right] - \frac{1}{2}\times(2+3)\times(4)^2$

$= 100 - 40 = 60$ J.

61. (a) : Distance (s) = 10 m; Force (F) = 5 N and work done (W) = 25 J.
Work done $(W) = Fs \cos\theta = 25$
$\therefore$ $25 = 5 \times 10 \cos\theta = 50 \cos\theta$
or $\cos q = 25/50 = 0.5$ or $\theta = 60°$.

62. (c) : Mass of body $(m_1) = m$; Velocity of first body (u_1) = 3 km/hour; Mass of second body in rest $(m_2) = 2m$ and velocity of second body $(u_2) = 0$.
After combination, mass of the body
$M = m + 2m = 3m$
From the law of conservation of momentum, we get
$Mv = m_1u_1 + m_2u_2$
or $3mv = (m \times 3) + (2m \times 0) = 3m$
or $v = 1$ km/hour.

63. (a) : $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$ or $-\frac{12a}{x^{13}} - \frac{-6b}{x^7} = 0$

or $x^6 = \frac{2a}{b}$. Therefore $x = \left(\frac{2a}{b}\right)^{1/6}$.

64. (a) : Force $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})$ N and distance $(d) = 10\hat{j}$ m.

Work done

$W = \vec{F}\cdot\vec{d} = (-2\hat{i}+15\hat{j}+6\hat{k})\cdot(10\hat{j}) = 150$ N-m = 150 J.

65. (b) : $v^2 = u^2 + 2as$ or $v^2 - u^2 = 2as$

or $v^2 - (0)^2 = 2\times\frac{F}{m}\times s$ or $v^2 = \frac{2Fs}{m}$ and

K.E. $= \frac{1}{2}mv^2 = \frac{1}{2}m\times\frac{2Fs}{m} = Fs$.

Thus K.E. is independent of m or directly proportional to m^0.

66. (a) : Force $(F) = 7 - 2x + 3x^2$; Mass (m) = 2 kg and displacement (d) = 5 m. Therefore work done

$(W) = \int F dx = \int_0^5 (7-2x+3x^2)dx = (7x-x^2+x^3)_0^5$

$= (7 \times 5) - (5)^2 + (5)^3 = 35 - 25 + 125 = 135$ J.

67. (a)

68. (c) : $\frac{K_1}{K_2} = \frac{p_1^2}{p_2^2}\times\frac{M_2^2}{M_1^2}$

when $K_1 = K_2$

$\frac{p_1}{p_2} = \sqrt{\frac{M_1}{M_2}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$

$\therefore$ $p_1 : p_2 = 1 : 3$

69. (c) : On the diametrically opposite points, the velocities have same magnitude but opposite directions. Therefore change in momentum is $Mv - (-Mv) = 2Mv$

70. (b) : Power $= \frac{\text{work done}}{\text{time taken}} = \frac{W}{t}$

but W = mass × gravity × height

$\therefore$ $P = \frac{M\times g\times h}{t}$

$\Rightarrow$ $M = \frac{p\times t}{g\times h} = \frac{2000\times60}{10\times10} = 1200$ kg.

i.e., 1200 litres as one litre has a mass of 1 kg.

71. (b) : Work done = change in kinetic energy of the body

$W = \frac{1}{2}\times0.01[(1000)^2 - (500)^2] = 3750$ joule.

72. (a) : Coefficient of restitution or resilience of two bodies is defined as the constant ratio of relative velocity after impact to the relative velocity of the bodies before impact when the two bodies collide head on. There velocities are in the opposite directions.

Thus $\frac{v_1 - v_2}{u_1 - u_2}$ = constant = $-e$

The constant e is known as coeff. of restitution or resilience of two bodies. For a perfectly elastic collision, $e = 1$ and for a perfectly inelastic collision, $e = 0$. Thus $0 \le e \le 1$.