Chapter 4

Work, Energy and Power

1. Statement-1 : Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.

   Statement-2 : Principle of conservation of momentum holds true for all kinds of collisions. **[AIEEE-2010]**

   (1) Statement-1 is true, Statement-2 is false

   (2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1

   (3) Statement-1 is true, Statement-2 is true; Statement-2 is the *not* the correct explanation of Statement-1

   (4) Statement-1 is false, Statement-2 is true

2. The potential energy function for the force between two atoms in a diatomic molecule is approximately given by $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$, where a and b are constants and x is the distance between the atoms. If the dissociation energy of the molecule is $D = [U(x = \infty) - U_{\text{at equilibrium}}]$, D is **[AIEEE-2010]**

   (1) $\frac{b^2}{6a}$ (2) $\frac{b^2}{2a}$

   (3) $\frac{b^2}{12a}$ (4) $\frac{b^2}{4a}$

3. At time $t = 0$ s a particle starts moving along the x-axis. If its kinetic energy increases uniformly with time t, the net force acting on it must be proportional to **[AIEEE-2011]**

   (1) $\frac{1}{\sqrt{t}}$ (2) $\sqrt{t}$

   (3) Constant (4) t

4. *This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.*

   If two springs S_1 and S_2 of force constants k_1 and k_2, respectively, are stretched by the same force, it is found that more work is done on spring S_1 than on spring S_2.

   Statement 1 : If stretched by the same amount, work done on S_1, will be more than that on S_2.

   Statement 2 : $k_1 < k_2$. **[AIEEE-2012]**

   (1) Statement 1 is true, Statement 2 is false

   (2) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation for Statement 1

   (3) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1

   (4) Statement 1 is false, Statement 2 is true

5. *This question has Statement-I and Statement-II. Of the four choices given after the Statements, choose the one that best describes the two Statements.*

   Statement-I: A point particle of mass m moving with speed v collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f = \left(\frac{m}{M+m}\right)$.

   Statement-II: Maximum energy loss occurs when the particles get stuck together as a result of the collision. **[JEE (Main)-2013]**

   (1) Statement-I is true, Statement-II is true, Statement-II is a correct explanation of Statement-I

   (2) Statement-I is true, Statement-II is true, Statement-II is not a correct explanation of Statement-I

   (3) Statement-I is true, Statement-II is false.

   (4) Statement-I is false, Statement-II is true.

6. When a rubber-band is stretched by a distance x, it exerts a 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 **[JEE (Main)-2014]**

(1) $aL^2 + bL^3$ (2) $\frac{1}{2}(aL^2 + bL^3)$

(3) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (4) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

7. A particle of mass m moving in the x direction with speed $2v$ is hit by another particle of mass $2m$ moving in the y direction wth speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to **[JEE (Main)-2015]**

(1) 44% (2) 50%

(3) 56% (4) 62%

8. A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies 3.8×10^7 J of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take $g = 9.8$ ms^{-2} **[JEE (Main)-2016]**

(1) 6.45×10^{-3} kg (2) 9.89×10^{-3} kg

(3) 12.89×10^{-3} kg (4) 2.45×10^{-3} kg

9. A body of mass $m = 10^{-2}$ kg is moving in a medium and experiences a frictional force $F = -kv^2$. Its initial speed is $v_0 = 10$ ms^{-1}. If, after 10 s, its energy is $\frac{1}{8}mv_0^2$, the value of k will be **[JEE (Main)-2017]**

(1) 10^{-3} kg m^{-1} (2) 10^{-3} kg s^{-1}

(3) 10^{-4} kg m^{-1} (4) 10^{-1} kg m^{-1} s^{-1}

10. A time dependent force $F = 6t$ acts on a particle of mass 1 kg. If the particle starts from rest, the work done by the force during the first 1 second will be **[JEE (Main)-2017]**

(1) 4.5 J (2) 22 J

(3) 9 J (4) 18 J

11. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energy is **[JEE (Main)-2018]**

(1) $-\frac{k}{4a^2}$ (2) $\frac{k}{2a^2}$

(3) Zero (4) $-\frac{3}{2}\frac{k}{a^2}$

12. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is **[JEE (Main)-2018]**

(1) $\frac{v_0}{4}$ (2) $\sqrt{2}v_0$

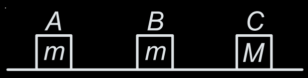
(3) $\frac{v_0}{2}$ (4) $\frac{v_0}{\sqrt{2}}$

13. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c. The values of p_d and p_c are respectively **[JEE (Main)-2018]**

(1) (0.89, 0.28) (2) (0.28, 0.89)

(3) (0, 0) (4) (0, 1)

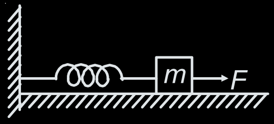
14. Three blocks A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M. Block A is given an initial speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C, also perfectly inelastically $\frac{5}{6}$th of the initial kinetic energy is lost in whole process. What is value of M/m? **[JEE (Main)-2019]**



(1) 3 (2) 4

(3) 2 (4) 5

15. A block of mass m, lying on a smooth horizontal surface, is attached to a spring (of negligible mass) of spring constant k. The other end of the spring is fixed, as shown in the figure. The block is initially at rest in its equilibrium position. If now the block is pulled with a constant force F, the maximum speed of the block is **[JEE (Main)-2019]**



(1) $\frac{F}{\pi\sqrt{mk}}$ (2) $\frac{\pi F}{\sqrt{mk}}$

(3) $\frac{2F}{\sqrt{mk}}$ (4) $\frac{F}{\sqrt{mk}}$

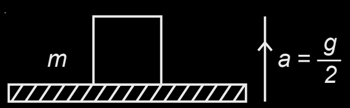
16. A force acts on a 2 kg object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds?

[JEE (Main)-2019]

(1) 950 J (2) 900 J

(3) 850 J (4) 875 J

17. A block of mass m is kept on a platform which starts from rest with constant acceleration $\frac{g}{2}$ upward, as shown in fig. Work done by normal reaction on block in time t is **[JEE (Main)-2019]**



(1) $\frac{3mg^2t^2}{8}$ (2) $-\frac{mg^2t^2}{8}$

(3) 0 (4) $\frac{mg^2t^2}{8}$

18. A piece of wood of mass 0.03 kg is dropped from the top of a 100 m height building. At the same time, a bullet of mass 0.02 kg is fired vertically upwards, with a velocity 100 ms^{-1}, from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is (g = 10 ms^{-2}) **[JEE (Main)-2019]**

(1) 30 m (2) 40 m

(3) 20 m (4) 10 m

19. A particle which is experiencing a force, given by $\vec{F} = 3\vec{i} - 12\vec{j}$, undergoes a displacement of $\vec{d} = 4\vec{i}$. If the particle had a kinetic energy of 3 J at the beginning of the displacement, what is its kinetic energy at the end of the displacement?

[JEE (Main)-2019]

(1) 15 J (2) 9 J

(3) 12 J (4) 10 J

20. A body of mass 1 kg falls freely from a height of 100 m, on a platform of mass 3 kg which is mounted on a spring having spring constant k = 1.25×10^6 N/m. The body sticks to the platform and the spring's maximum compression is found to be x. Given that g = 10 ms^{-2}, the value of x will be close to **[JEE (Main)-2019]**

(1) 80 cm (2) 8 cm

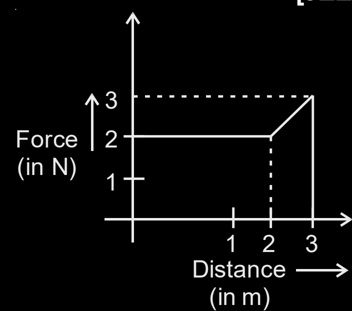
(3) 2 cm (4) 40 cm

21. A simple pendulum, made of a string of length l and a bob of mass m, is released from a small angle θ_0. It strikes a block of mass M, kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle θ_1. Then M is given by **[JEE (Main)-2019]**

(1) $m\left(\frac{\theta_0 + \theta_1}{\theta_0 - \theta_1}\right)$ (2) $\frac{m}{2}\left(\frac{\theta_0 - \theta_1}{\theta_0 + \theta_1}\right)$

(3) $\frac{m}{2}\left(\frac{\theta_0 + \theta_1}{\theta_0 - \theta_1}\right)$ (4) $m\left(\frac{\theta_0 - \theta_1}{\theta_0 + \theta_1}\right)$

22. A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3 m is **[JEE (Main)-2019]**



(1) 4 J (2) 2.5 J

(3) 5 J (4) 6.5 J

23. A body of mass m_1 moving with an unknown velocity of $v_1\hat{i}$, undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and m_2 move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively. If $m_2 = 0.5\, m_1$ and $v_3 = 0.5\, v_1$, then v_1 is **[JEE (Main)-2019]**

(1) $v_4 - \frac{v_2}{4}$

(2) $v_4 - v_2$

(3) $v_4 + v_2$

(4) $v_4 - \frac{v_2}{2}$

24. A uniform cable of mass M and length L is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be **[JEE (Main)-2019]**

(1) $\frac{MgL}{n^2}$ (2) $nMgL$

(3) $\frac{MgL}{2n^2}$ (4) $\frac{2MgL}{n^2}$

25. A body of mass 2 kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body? **[JEE (Main)-2019]**

(1) 1.5 kg (2) 1.8 kg

(3) 1.0 kg (4) 1.2 kg

26. A wedge of mass $M = 4\ m$ lies on a frictionless plane. A particle of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by **[JEE (Main)-2019]**

(1) $\frac{v^2}{g}$ (2) $\frac{2v^2}{5g}$

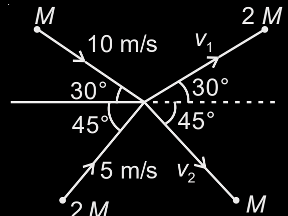
(3) $\frac{2v^2}{7g}$ (4) $\frac{v^2}{2g}$

27. A particle of mass 'm' is moving with speed '$2v$' and collides with a mass '$2m$' moving with speed 'v' in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass 'm', which move at angle 45° with respect to the original direction. The speed of each of the moving particle will be **[JEE (Main)-2019]**

(1) $v/(2\sqrt{2})$ (2) $v/\sqrt{2}$

(3) $\sqrt{2}v$ (4) $2\sqrt{2}v$

28. Two particles, of masses M and $2M$, moving, as shown, with speeds of 10 m/s and 5 m/s, collide elastically at the origin. After the collision, they move along the indicated directions with speeds v_1 and v_2, respectively. The values of v_1 and v_2 are nearly: **[JEE (Main)-2019]**



(1) 3.2 m/s and 12.6 m/s

(2) 3.2 m/s and 6.3 m/s

(3) 6.5 m/s and 3.2 m/s

(4) 6.5 m/s and 6.3 m/s

29. A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to (1 HP = 746 W, g = 10 ms^{-2}) **[JEE (Main)-2020]**

(1) 1.5 ms^{-1} (2) 1.9 ms^{-1}

(3) 1.7 ms^{-1} (4) 2.0 ms^{-1}

30. An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being 68 kg. The mass of the elevator itself is 920 kg and it moves with a constant speed of 3 m/s. The frictional force opposing the motion is 6000 N. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator (g = 10 m/s^2) must be at least **[JEE (Main)-2020]**

(1) 56300 W (2) 66000 W

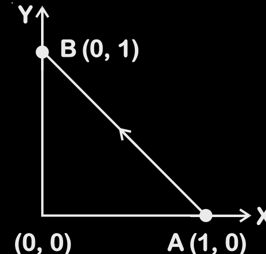
(3) 48000 W (4) 62360 W

31. A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is **[JEE (Main)-2020]**

(1) $\sqrt{\frac{1}{2}}$ (2) $\sqrt{\frac{3}{4}}$

(3) $\frac{1}{2}$ (4) $\sqrt{\frac{3}{2}}$

32. Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point $A(1, 0)$ to $B(0, 1)$ along the line segment is (all quantities are in SI units) **[JEE (Main)-2020]**



(1) 2 (2) 1

(3) $\frac{1}{2}$ (4) $\frac{3}{2}$

33. Two particles of equal mass m have respective initial velocities $u\hat{i}$ and $u\left(\dfrac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is **[JEE (Main)-2020]**

(1) $\sqrt{\dfrac{2}{3}}\,mu^2$ (2) $\dfrac{3}{4}mu^2$

(3) $\dfrac{1}{8}mu^2$ (4) $\dfrac{1}{3}mu^2$

34. A particle of mass m is projected with a speed u from the ground at an angle $\theta = \dfrac{\pi}{3}$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is **[JEE (Main)-2020]**

(1) $\dfrac{5}{8}\dfrac{u^2}{g}$ (2) $\dfrac{3\sqrt{2}}{4}\dfrac{u^2}{g}$

(3) $\dfrac{3\sqrt{3}}{8}\dfrac{u^2}{g}$ (4) $2\sqrt{2}\dfrac{u^2}{g}$

35. A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3 m at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by **[JEE (Main)-2020]**

(1) $v = \dfrac{1}{\sqrt{6}}u$ (2) $v = \dfrac{u}{\sqrt{3}}$

(3) $v = \sqrt{\dfrac{2}{3}}\,u$ (4) $v = \dfrac{u}{\sqrt{2}}$

36. A block of mass 1.9 kg is at rest at the edge of a table, of height 1 m. A bullet of mass 0.1 kg collides with the block and sticks to it. If the velocity of the bullet is 20 m/s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is [Take g = 10 m/s^2. Assume there is no rotational motion and loss of energy after the collision is negligable.] **[JEE (Main)-2020]**

(1) 19 J

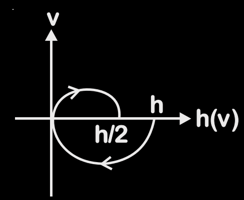
(2) 23 J

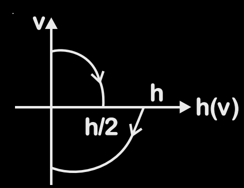
(3) 20 J

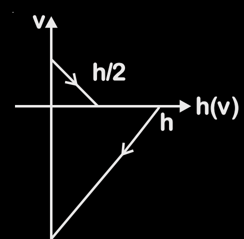
(4) 21 J

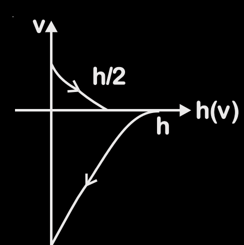
37. A tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\dfrac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by

(graph are drawn schematically and on not to scale) **[JEE (Main)-2020]**

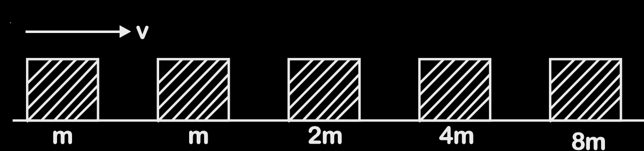
(1) 

(2) 

(3) 

(4) 

38. Blocks of masses m, 2 m, 4 m and 8 m are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass 8 m starts moving the total energy loss is p% of the original energy. Value of 'p' is close to **[JEE (Main)-2020]**



(1) 37 (2) 77

(3) 87 (4) 94

39. A person pushes a box on a rough horizontal platform surface. He applies a force of 200 N over a distance of 15 m. Thereafter, he gets progressively tired and his applied force reduces linearly with distance to 100 N. The total distance through which the box has been moved is 30 m. What is the work done by the person during the total movement of the box? **[JEE (Main)-2020]**

(1) 5690 J (2) 3280 J

(3) 5250 J (4) 2780 J

40. If the potential energy between two molecules is given by $U = -\frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are **[JEE (Main)-2020]**

(1) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$ (2) $\left(\frac{B}{2A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$

(3) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{4B}$ (4) $\left(\frac{B}{A}\right)^{\frac{1}{6}}, 0$

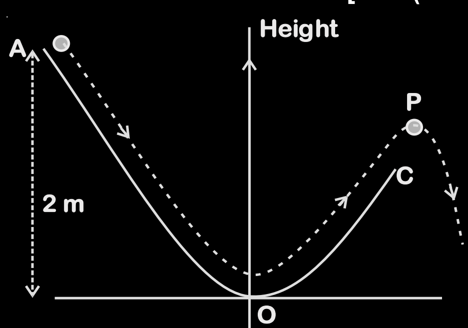
41. Particle *A* of mass m_1 moving with velocity $(\sqrt{3}\hat{i} + \hat{j})\,\text{ms}^{-1}$ collides with another particle *B* of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles *A* and *B* after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{V}_1 = (\hat{i} + \sqrt{3}\hat{j})\,\text{ms}^{-1}$, the angle between $\vec{V}_1$ and $\vec{V}_2$ is **[JEE (Main)-2020]**

(1) –45° (2) 60°

(3) 15° (4) 105°

42. A particle (m = 1 kg) slides down a frictionless track (*AOC*) starting from rest at a point *A* (height 2 m). After reaching *C*, the particle continues to move freely in air as a projectile. When it reaching its highest point *P* (height 1 m), the kinetic energy of the particle (in J) is (figure drawn is schematic and not to scale; take g = 10 ms^{-2})

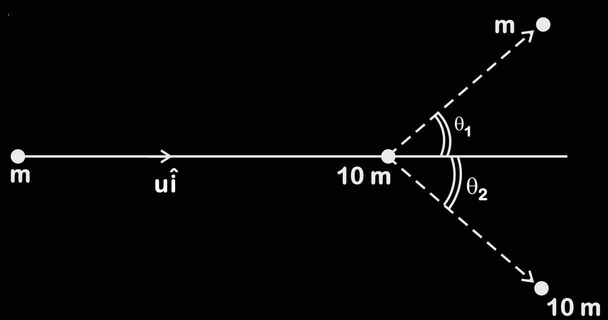
[JEE (Main)-2020]



43. A body *A*, of mass m = 0.1 kg has an initial velocity of $3\hat{i}$ ms^{-1}. It collides elastically with another body, *B* of the same mass which has an initial velocity of $5\hat{j}$ ms^{-1}. After collision, *A* moves with a velocity $\vec{v} = 4(\hat{i} + \hat{j})\,\text{ms}^{-1}$. The energy of *B* after collision is written as $\frac{x}{10}$ J. The value of x is ________. **[JEE (Main)-2020]**

44. A particle of mass m is moving along the *x*-axis with initial velocity $u\hat{i}$. It collides elastically with a particle of mass 10 m at rest and then moves with half its initial kinetic energy (see figure). If $\sin\theta_1 = \sqrt{n}\sin\theta_2$ then value of n is ________.

[JEE (Main)-2020]



45. A cricket ball of mass 0.15 kg is thrown vertically up by a bowling machine so that it rises to a maximum height of 20 m after leaving the machine. If the part pushing the ball applies a constant force *F* on the ball and moves horizontally a distance of 0.2 m while launching the ball, the value of *F* (in N) is (g = 10 ms^{-2}) ____.

[JEE (Main)-2020]

46. A block starts moving up an inclined plane of inclination 30° with an initial velocity of v_0. It comes back to its initial position with velocity $\frac{v_0}{2}$. The value of the coefficient of kinetic friction between the block and the inclined plane is close to $\frac{I}{1000}$. The nearest integer to *I* is ________.

[JEE (Main)-2020]

47. A body of mass 2 kg is driven by an engine delivering a constant power of 1 J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) ________. **[JEE (Main)-2020]**

48. Two bodies of the same mass are moving with the same speed, but in different directions in a plane. They have a completely inelastic collision and move together thereafter with a final speed which is half of their initial speed. The angle between the initial velocities of the two bodies (in degree) is ________. **[JEE (Main)-2020]**

49. A ball with a speed of 9 m/s collides with another identical ball at rest. After the collision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is x : y, where x is ________.

[JEE (Main)-2021]

50. A particle is projected with velocity v_0 along x-axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e. $ma = -\alpha x^2$. The distance at which the particle stops **[JEE (Main)-2021]**

(1) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$ (2) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{2}}$

(3) $\left(\frac{2v_0^2}{3\alpha}\right)^{\frac{1}{2}}$ (4) $\left(\frac{2v_0}{3\alpha}\right)^{\frac{1}{3}}$

51. Two solids A and B of mass 1 kg and 2 kg respectively are moving with equal linear momentum. The ratio of their kinetic energies $(K.E)_A : (K.E.)_B$ will be $\frac{A}{1}$, so the value of A will be________. **[JEE (Main)-2021]**

52. A small bob tied at one end of a thin string of length 1 m is describing a vertical circle so that the maximum and minimum tension in the string are in the ratio 5 : 1. The velocity of the bob at the highest position is________ m/s. (Take $g = 10\ m/s^2$)

[JEE (Main)-2021]

53. The potential energy (U) of a diatomic molecule is a function dependent on r (interatomic distance) as

$$U = \frac{\alpha}{r^{10}} - \frac{\beta}{r^5} - 3$$

where α and β are positive constants. The equilibrium distance between two atoms will be

$\left(\frac{2\alpha}{\beta}\right)^{\frac{a}{b}}$, where a = ______________.

[JEE (Main)-2021]

54. Two particles having masses 4 g and 16 g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their momentum is n : 2. The value of n will **[JEE (Main)-2021]**

55. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Body 'P' having mass M moving with speed 'u' has head-on collision elastically with another body 'Q' having mass 'm' initially at rest. If m << M, body 'Q' will have a maximum speed equal to '2u' after collision.

Reason R: During elastic collision, the momentum and kinetic energy are both conserved.

In the light of the above statements, choose the most appropriate answer from the options given below : **[JEE (Main)-2021]**

(1) Both A and R are correct and R is the correct explanation of A

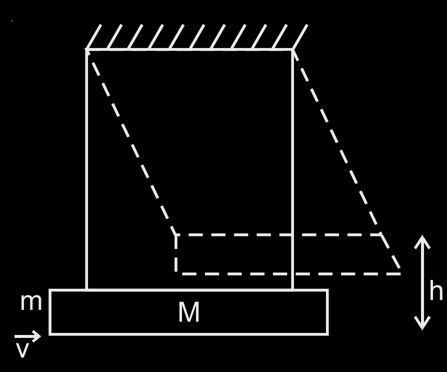
(2) A is not correct but R is correct

(3) A is correct but R is not correct

(4) Both A and R are correct but R is NOT the correct explanation of A

56. A large block of wood of mass M = 5.99 kg is hanging from two long massless cords. A bullet of mass m = 10 g is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising a vertical distance h = 9.8 cm before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is : **[JEE (Main)-2021]**

(take $g = 9.8\ ms^{-2}$)



(1) 821.4 m/s

(2) 831.4 m/s

(3) 841.4 m/s

(4) 811.4 m/s

57. A boy is rolling a 0.5 kg ball on the frictionless floor with the speed of 20 ms^{-1}. The ball gets deflected by an obstacle on the way. After deflection it moves with 5% of its initial kinetic energy. What is the speed of the ball now? **[JEE (Main)-2021]**

(1) 4.47 ms^{-1} (2) 1.00 ms^{-1}

(3) 14.41 ms^{-1} (4) 19.0 ms^{-1}

58. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball. (Take g = 10 ms^{-2})

[JEE (Main)-2021]

(1) 3.50 ms^{-1}

(2) 2.0 ms^{-1}

(3) 2.50 ms^{-1}

(4) 3.0 ms^{-1}

59. A constant power delivering machine has towed a box, which was initially at rest, along a horizontal straight line. The distance moved by the box in time 't' is proportional to: **[JEE (Main)-2021]**

(1) $t^{3/2}$ (2) $t^{2/3}$

(3) t (4) $t^{1/2}$

60. A bullet of mass 0.1 kg is fired on a wooden block to pierce through it, but it stops after moving a distance of 50 cm into it. If the velocity of bullet before hitting the wood is 10 m/s and it slows down with uniform deceleration, then the magnitude of effective retarding force on the bullet is 'x' N.

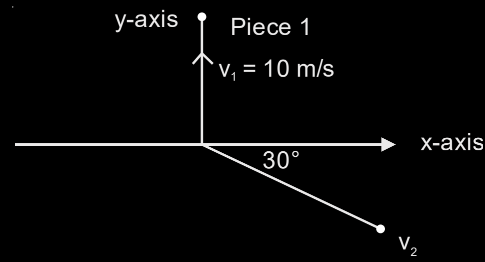
The value of 'x' to the nearest integer is ______.

[JEE (Main)-2021]

61. A ball of mass 10 kg moving with a velocity $10\sqrt{3}$ m/s along the x-axis, hits another ball of mass 20 kg which is at rest. After the collision, first ball comes to rest while the second ball disintegrates into two equal pieces. One piece starts moving along y-axis with a speed of 10 m/s. The second piece starts moving at an angle of 30° with respect to the x-axis.

The velocity of the ball moving at 30° with x-axis is x m/s.

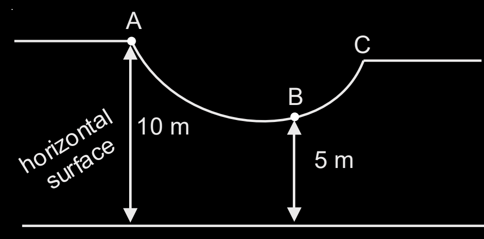
The configuration of pieces after collision is shown in the figure below.



The value of x to the nearest integer is ______.

[JEE (Main)-2021]

62.



As shown in the figure, a particle of mass 10 kg is placed at a point A. When the particle is slightly displaced to its right, it starts moving and reaches the point B. The speed of the particle at B is x m/s. (Take g = 10 m/s^2)

The value of 'x' to the nearest integer is________.

[JEE (Main)-2021]

63. An object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is:

[JEE (Main)-2021]

(1) 2 : 1

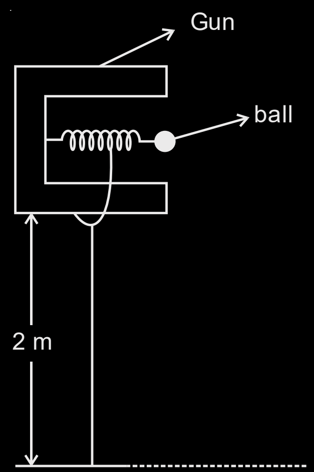
(2) 3 : 1

(3) 1 : 2

(4) 1 : 1

64. A ball of mass 4 kg, moving with a velocity of 10 ms^{-1}, collides with a spring of length 8 m and force constant 100 Nm^{-1}. The length of the compressed spring is x m. The value of x, to the nearest integer, is ______. **[JEE (Main)-2021]**

65. In a spring gun having spring constant 100 N/m a small ball 'B' of mass 100 g is put in its barrel (as shown in figure) by compressing the spring through 0.05 m. There should be a box placed at a distance '*d*' on the ground so that the ball falls in it. If the ball leaves the gun horizontally at a height of 2 m above the ground. The value of *d* is ____________ m. (g = 10 m/s^2). **[JEE (Main)-2021]**



66. If the Kinetic energy of a moving body becomes four times its initial Kinetic energy, then the percentage change in its momentum will be:

[JEE (Main)-2021]

(1) 200% (2) 100%

(3) 400% (4) 300%

67. A body at rest is moved along a horizontal straight line by a machine delivering a constant power. The distance moved by the body in time '*t*' is proportional to **[JEE (Main)-2021]**

(1) $t^{\frac{1}{2}}$ (2) $t^{\frac{1}{4}}$

(3) $t^{\frac{3}{2}}$ (4) $t^{\frac{3}{4}}$

68. A porter lifts a heavy suitcase of mass 80 kg and at the destination lowers it down by a distance of 80 cm with a constant velocity. Calculate the workdone by the porter in lowering the suitcase.

(take g = 9.8 ms^{-2}) **[JEE (Main)-2021]**

(1) +627.2 J

(2) –62720.0 J

(3) –627.2 J

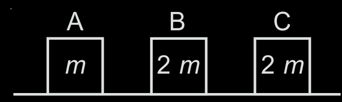
(4) 784.0 J

69. A force of F = $(5y+20)\hat{j}$ N acts on a particle. The workdone by this force when the particle is moved from y = 0 m to y = 10 m is _______ J.

[JEE (Main)-2021]

70. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are *m*, 2 *m* and 2 *m* respectively. A moves towards B with a speed of 9 m/s and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along same straight line. The final speed of C is

[JEE (Main)-2021]



(1) 6 m/s (2) 4 m/s

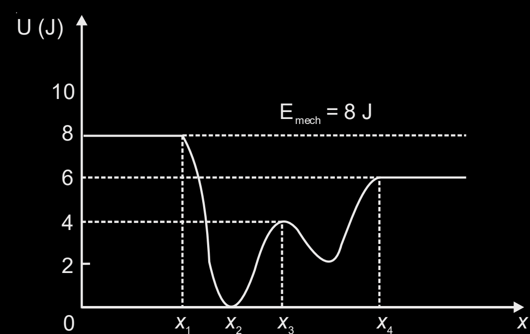
(3) 9 m/s (4) 3 m/s

71. A stone of mass 20 g is projected from a rubber catapult of length 0.1 m and area of cross section 10^{-6} m^2 stretched by an amount 0.04 m. The velocity of the projected stone is ______ m/s.

(Young's modulus of rubber = 0.5 × 10^9 N/m^2)

[JEE (Main)-2021]

72. Given below is the plot of a potential energy function U(x) for a system, in which a particle is in one dimensional motion, while a conservative force F(x) acts on it. Suppose that E_{mech} = 8 J, the incorrect statement for this system is : **[JEE (Main)-2021]**



[where K.E. = kinetic energy]

(1) At $x < x_1$, K.E. is smallest and the particle is moving at the slowest speed.

(2) At $x > x_4$, K.E. is constant throughout the region.

(3) At $x = x_2$, K.E. is greatest and the particle is moving at the fastest speed.

(4) At $x = x_3$, K.E. = 4 J.

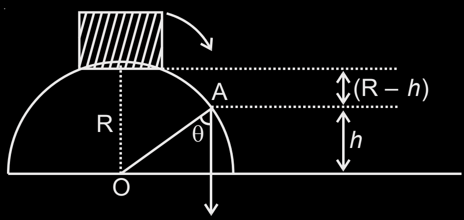
73. An automobile of mass '*m*' accelerates starting from origin and initially at rest, while the engine supplies constant power P. The position is given as a function of time by **[JEE (Main)-2021]**

(1) $\left(\frac{9P}{8m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$ (2) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

(3) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{2}{3}}$ (4) $\left(\frac{9m}{8P}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

74. A small block slides down from the top of hemisphere of radius R = 3 m as shown in the figure. The height 'h' at which the block will lose contact with the surface of the sphere is ______ m.

(Assume there is no friction between the block and the hemisphere) **[JEE (Main)-2021]**



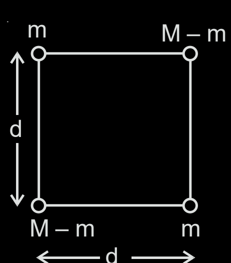
75. A uniform chain of length 3 meter and mass 3 kg overhangs a smooth table with 2 meter laying on the table. If k is the kinetic energy of the chain in Joule as it completely slips off the table, then the value of k is ______. (Take g = 10 m/s^2) **[JEE (Main)-2021]**

76. Two persons A and B perform same amount of work in moving a body through a certain distance d with application of forces acting at angles 45° and 60° with the direction of displacement respectively. The ratio of force applied by person A to the force applied by person B is $\frac{1}{\sqrt{x}}$. The value of x is ______

[JEE (Main)-2021]

77. A body of mass (2M) splits into four masses {m, M – m, m, M – m}, which are rearranged to form a square as shown in the figure. The ratio of $\frac{M}{m}$ for which, the gravitational potential energy of the system becomes maximum is x : 1. The value of x is _______.

[JEE (Main)-2021]



78. A body of mass M moving at speed V_0 collides elastically with a mass 'm' at rest. After the collision, the two masses move at angles θ_1 and θ_2 with respect to the initial direction of motion of the body of mass M. The largest possible value of the ratio M/m, for which the angles θ_1 and θ_2 will be equal, is:

[JEE (Main)-2021]

(1) 4
(2) 2
(3) 1
(4) 3

79. A block moving horizontally on a smooth surface with a speed of 40 m/s splits into two parts with masses in the ratio of 1 : 2. If the smaller part moves at 60 m/s in the same direction, then the fractional change in kinetic energy is: **[JEE (Main)-2021]**

(1) $\frac{1}{3}$

(2) $\frac{2}{3}$

(3) $\frac{1}{4}$

(4) $\frac{1}{8}$

80. A body of mass 'm' dropped from a height 'h' reaches the ground with a speed of 0.8 $\sqrt{gh}$. The value of work done by the air-friction is:

[JEE (Main)-2021]

(1) mgh
(2) 0.64 mgh
(3) 1.64 mgh
(4) –0.68 mgh

81. An engine is attached to a wagon through a shock absorber of length 1.5 m. The system with a total mass of 40,000 kg is moving with a speed of 72 kmh^{-1} when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, the spring constant is ________ × 10^5 N/m.

[JEE (Main)-2021]

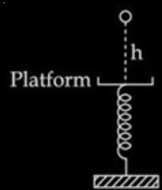
82. A particle experiences a variable force $\vec{F} = \left(4x\hat{i} + 3y^2\hat{j}\right)$ in a horizontal x-y plane. Assume distance in meters and force is newton. If the particle moves from point (1, 2) to point (2, 3) in the x-y plane; then Kinetic Energy changes by

[JEE (Main)-2022]

(1) 50.0 J
(2) 12.5 J
(3) 25.0 J
(4) 0 J

83. A ball of mass 100 g is dropped from a height h =10 cm on a platform fixed at the top of a vertical spring (as shown in figure). The ball stays on the platform and the platform is depressed by a distance $\frac{h}{2}$. The spring constant is _______ Nm^{-1}.

(Use g = 10 ms^{-2}) **[JEE (Main)-2022]**



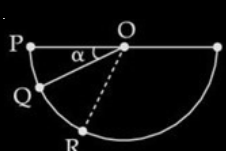
84. A 0.5 kg block moving at a speed of 12 ms^{-1} compresses a spring through a distance 30 cm when its speed is halved. The spring constant of the spring will be ___ Nm^{-1}. **[JEE (Main)-2022]**

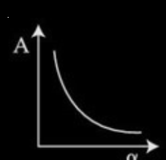
85. An object is thrown vertically upwards. At its maximum height, which of the following quantity becomes zero? **[JEE (Main)-2022]**

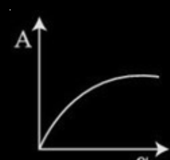
(1) Momentum (2) Potential Energy

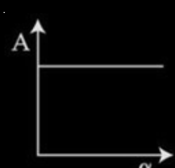
(3) Acceleration (4) Force

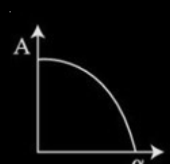
86. A ball is released from rest from point P of a smooth semi-spherical vessel as shown in figure. The ratio of the centripetal force and normal reaction on the ball at point Q is A while angular position of point Q is α with respect to point P. Which of the following graphs represent the correct relation between A and α when ball goes from Q to R? **[JEE (Main)-2022]**



(1) 

(2) 

(3) 

(4) 

87. A pendulum of length 2 m consists of a wooden bob of mass 50 g. A bullet of mass 75 g is fired towards the stationary bob with a speed v. The bullet emerges out of the bob with a speed $\frac{v}{3}$ and the bob just completes the vertical circle. The value of v is _______ ms^{-1}. (if g =10 m/s^2). **[JEE (Main)-2022]**

88. A stone tied to a string of length L is whirled in a vertical circle with the other end of the string at the centre. At a certain instant of time, the stone is at its lowest position and has a speed u. The magnitude of change in its velocity, as it reaches a position where the string is horizontal, is $\sqrt{x(u^2 - gL)}$. The value of x is **[JEE (Main)-2022]**

(1) 3 (2) 2

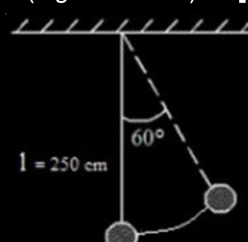
(3) 1 (4) 5

89. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is given as **[JEE (Main)-2022]**

(1) Zero (2) $mk^2r^2t^2$

(3) mk^2r^2t (4) mk^2rt

90. A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200 g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob, the maximum velocity attained by the bob will be ___ ms^{-1}. (if g = 10 m/s^2) **[JEE (Main)-2022]**



91. A block of mass 2 kg moving on a horizontal surface with speed of 4 ms^{-1} enters a rough surface ranging from x = 0.5 m to x = 1.5 m. The retarding force in this range of rough surface is related to distance by $F = -kx$ where k = 12 Nm^{-1}. The speed of the block as it just crosses the rough surface will be :

[JEE (Main)-2022]

(1) Zero (2) 1.5 ms^{-1}

(3) 2.0 ms^{-1} (4) 2.5 ms^{-1}

92. Water falls from a 40 m high dam at the rate of 9×10^4 kg per hour. Fifty percentage of gravitational potential energy can be converted into electrical energy. Using this hydro electric energy number of 100 W lamps, that can be lit, is :

(Take $g = 10\ ms^{-2}$) **[JEE (Main)-2022]**

(1) 25 (2) 50

(3) 100 (4) 18

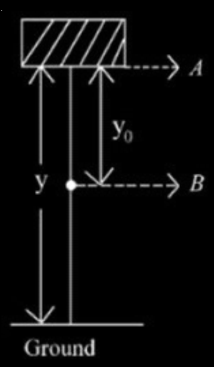
93. A particle of mass 500 gm is moving in a straight line with velocity $v = bx^{5/2}$. The work done by the net force during its displacement from $x = 0$ to $x = 4$ m is : (Take $b = 0.25\ m^{-3/2}s^{-1}$). **[JEE (Main)-2022]**

(1) 2 J (2) 4 J

(3) 8 J (4) 16 J

94. In the given figure, the block of mass m is dropped from the point 'A'. The expression for kinetic energy of block when it reaches point 'B' is

[JEE (Main)-2022]



(1) $\frac{1}{2}mgy_0^2$ (2) $\frac{1}{2}mgy^2$

(3) $mg(y - y_0)$ (4) mgy_0

95. A body of mass 0.5 kg travels on straight line path with velocity $v = (3x^2 + 4)$ m/s. The net work done by the force during its displacement from $x = 0$ to $x = 2$ m is **[JEE (Main)-2022]**

(1) 64 J

(2) 60 J

(3) 120 J

(4) 128 J

96. Two billiard balls of mass 0.05 kg each moving in opposite directions with $10\ ms^{-1}$ collide and rebound with the same speed. If the time duration of contact is $t = 0.005$ s, then what is the force exerted on the ball due to each other? **[JEE (Main)-2022]**

(1) 100 N (2) 200 N

(3) 300 N (4) 400 N

97. A bag of sand of mass 9.8 kg is suspended by a rope. A bullet of 200 g travelling with speed $10\ ms^{-1}$ gets embedded in it, then loss of kinetic energy will be **[JEE (Main)-2022]**

(1) 4.9 J (2) 9.8 J

(3) 14.7 J (4) 19.6 J

98. As per the given figure, two blocks each of mass 250 g are connected to a spring of spring constant $2\ Nm^{-1}$. If both are given velocity v in opposite directions, then maximum elongation of the spring is: **[JEE (Main)-2022]**

(1) $\frac{v}{2\sqrt{2}}$ (2) $\frac{v}{2}$

(3) $\frac{v}{4}$ (4) $\frac{v}{\sqrt{2}}$

99. Sand is being dropped from a stationary dropper at a rate of $0.5\ kgs^{-1}$ on a conveyor belt moving with a velocity of $5\ ms^{-1}$. The power needed to keep the belt moving with the same velocity will be

[JEE (Main)-2022]

(1) 1.25 W (2) 2.5 W

(3) 6.25 W (4) 12.5 W

100. Two cylindrical vessels of equal cross-sectional area $16\ cm^2$ contain water upto heights 100 cm and 150 cm respectively. The vessels are interconnected so that the water levels in them become equal. The work done by the force of gravity during the process, is [Take, density of water = $10^3\ kg/m^3$ and $g = 10\ ms^{-2}$] **[JEE (Main)-2022]**

(1) 0.25 J (2) 1 J

(3) 8 J (4) 12 J

101. In two different experiments, an object of mass 5 kg moving with a speed of 25 ms^{-1} hits two different walls and comes to rest within (i) 3 second, (ii) 5 seconds, respectively. **[JEE (Main)-2022]**

Choose the **correct** option out of the following:

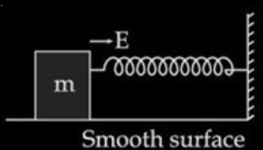
(1) Impulse and average force acting on the object will be same for both the cases.

(2) Impulse will be same for both the cases but the average force will be different.

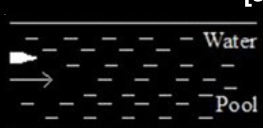
(3) Average force will be same for both the cases but the impulse will be different.

(4) Average force and impulse will be different for both the cases.

102. A block of mass '*m*' (as shown in figure) moving with kinetic energy *E* compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be *nE* Nm^{-1} for *n* = _______. **[JEE (Main)-2022]**



103. A bullet of mass 200 g having initial kinetic energy 90 J is shot inside a long swimming pool as shown in the figure. If it's kinetic energy reduces to 40 J within 1 s, the minimum length of the pool, the bullet has to travel so that it completely comes to rest is **[JEE (Main)-2022]**



(1) 45 m (2) 90 m

(3) 125 m (4) 25 m

104. The velocity of the bullet becomes one third after it penetrates 4 cm in a wooden block. Assuming that bullet is facing a constant resistance during its motion in the block. The bullet stops completely after travelling at (4 + *x*) cm inside the block. The value of *x* is **[JEE (Main)-2022]**

(1) 2.0 (2) 1.0

(3) 0.5 (4) 1.5

105. Arrange the four graphs in descending order of total work done; where W_1, W_2, W_3 and W_4 are the work done corresponding to figure *a*, *b*, *c* and *d* respectively. **[JEE (Main)-2022]**

Figure-a

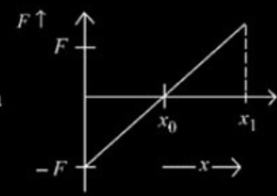


Figure-b

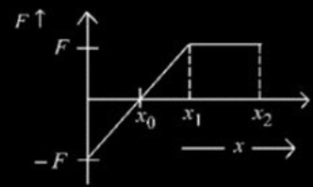


Figure-c

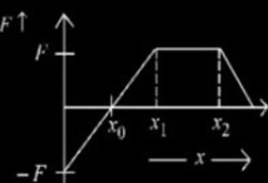
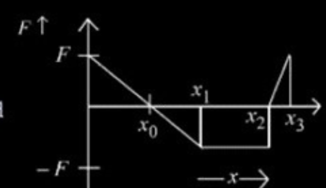


Figure-d



(1) $W_3 > W_2 > W_1 > W_4$

(2) $W_3 > W_2 > W_4 > W_1$

(3) $W_2 > W_3 > W_4 > W_1$

(4) $W_2 > W_3 > W_1 > W_4$

106. A stone of mass *m* tied to a string is being whirled in a vertical circle with a uniform speed. The tension in the string is **[JEE (Main)-2022]**

(1) The same throughout the motion.

(2) Minimum at the highest position of the circular path.

(3) Minimum at the lowest position of the circular path.

(4) Minimum when the rope is in the horizontal position.

Chapter 4

Work, Energy and Power

1. Answer (2)

If the particle moving in same direction lose all their energy, final momentum will become zero, whereas initial momentum is not zero.

2. Answer (4)

$$U = \frac{a}{x^{12}} - \frac{b}{x^6}$$

At equilibrium $\frac{dU}{dx} = 0$

$$\Rightarrow \frac{-12a}{x^{13}} + \frac{6b}{x^7} = 0$$

$$\Rightarrow \frac{12a}{x^{13}} = \frac{6b}{x^7}$$

$$\Rightarrow x^6 = \frac{2a}{b}$$

$$\Rightarrow U_{(\text{at equilibrium})} = \frac{a}{\left(\frac{2a}{b}\right)^2} - \frac{b}{\left(\frac{2a}{b}\right)} = \frac{b^2}{4a} - \frac{b^2}{2a} = \frac{-b^2}{4a}$$

At $x = \infty$, $U = 0$

$$\Rightarrow D = \frac{b^2}{4a}$$

3. Answer (1)

$k \propto t$

$\Rightarrow v^2 \propto t$

or $v \propto \sqrt{t}$

$$\frac{dv}{dt} \propto \frac{1}{\sqrt{t}}$$

4. Answer (4)

5. Answer (4)

Maximum energy loss is

$$\frac{1}{2}\frac{Mm}{M+m}(v-0)^2 = \frac{M}{M+m}\left(\frac{1}{2}mv^2\right)$$

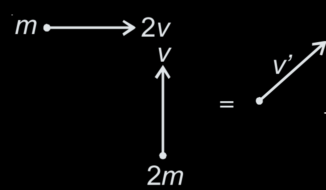
So, Statement-1 is wrong.

6. Answer (3)

$$\int dW = \int F \cdot dl$$

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

7. Answer (3)



$$\frac{2mv\sqrt{2}}{3m} = v'$$

$$\text{KE loss} = \frac{1}{2}m(2v)^2 + \frac{1}{2}(2m)v^2$$

$$-\frac{1}{2}\times(3m)\left(\frac{2mv\sqrt{2}}{3m}\right)^2 = \frac{5}{3}mv^2$$

$$\text{Required \%} = \frac{\frac{5}{3}mv^2}{2mv^2 + mv^2} \times 100 = 56\%$$

8. Answer (3)

Let x kg of fat is burned then

$$x \times 3.8 \times 10^7 \times \frac{20}{100} = 10 \times 9.8 \times 1000$$

$\Rightarrow x = 12.89 \times 10^{-3}$ kg

9. Answer (3)

$$\frac{k_f}{k_i} = \frac{\frac{1}{8}mv_0^2}{\frac{1}{2}mv_0^2} = \frac{1}{4}$$

$$\frac{v_f}{v_i} = \frac{1}{2}$$

$$v_f = \frac{v_0}{2}$$

$$-kv^2 = \frac{mdv}{dt}$$

$$\int_{v_0}^{\frac{v_0}{2}} \frac{dv}{v^2} = \int_0^{t_0} \frac{-kdt}{m}$$

$$\left[-\frac{1}{v}\right]_{v_0}^{\frac{v_0}{2}} = \frac{-k}{m}t_0$$

$$\frac{1}{v_0} - \frac{2}{v_0} = -\frac{k}{m}t_0$$

$$-\frac{1}{v_0} = -\frac{k}{m}t_0$$

$$k = \frac{m}{v_0 t_0} = \frac{10^{-2}}{10 \times 10} = 10^{-4} \text{ kg m}^{-1}$$

10. Answer (1)

$$6t = 1 \cdot \frac{dv}{dt}$$

$$\int_0^v dv = \int 6t\ dt$$

$$v = 6\left[\frac{t^2}{2}\right]_0^1 = 3 \text{ ms}^{-1}$$

$$W = \Delta\text{KE} = \frac{1}{2} \times 1 \times 9 = 4.5 \text{ J}$$

11. Answer (3)

$$F = \frac{-dU}{dr} \qquad \left[U = -\frac{k}{2r^2}\right]$$

$$\frac{mv^2}{r} = \frac{k}{r^3}$$ [This force provides necessary centripetal force]

$$\Rightarrow mv^2 = \frac{k}{r^2}$$

$$\Rightarrow \text{K.E} = \frac{k}{2r^2}$$

$$\Rightarrow \text{P.E} = -\frac{k}{2r^2}$$

Total energy = Zero

12. Answer (2)

It is a case of superelastic collision

$mv_0 = mv_1 + mv_2$ ...(i)

$\Rightarrow v_1 + v_2 = v_0$

$$\frac{1}{2}m\left(v_1^2 + v_2^2\right) = \frac{3}{2}\left(\frac{1}{2}mv_0^2\right)$$

$$\Rightarrow \left(v_1^2 + v_2^2\right) = \frac{3}{2}v_0^2 \quad \text{...(ii)}$$

$$\Rightarrow (v_1 + v_2)^2 = v_1^2 + v_2^2 + 2v_1v_2$$

$$\Rightarrow v_0^2 = \frac{3v_0^2}{2} + 2v_1v_2$$

$$\Rightarrow 2v_1v_2 = -\frac{v_0^2}{2} \quad \text{...(iii)}$$

$\therefore (v_1 - v_2)^2 = (v_1 + v_2)^2 - 4v_1v_2 = v_0^2 + v_0^2$

$$\Rightarrow v_1 - v_2 = \sqrt{2}v_0$$

13. Answer (1)

$mu = mv_1 + 2m \times v_2$ ...(i)

$u = (v_2 - v_1)$ ...(ii)

$$\Rightarrow v_1 = -\frac{u}{3}$$

$$\therefore \frac{\Delta E}{E} = p_d = \frac{\frac{1}{2}mu^2 - \frac{1}{2}m\left(\frac{u}{3}\right)^2}{\frac{1}{2}mu^2} = \frac{8}{9} = 0.89$$

And $mu = mv_1 + (12m) \times v_2$ ...(iii)

$u = (v_2 - v_1)$ ...(iv)

$$\Rightarrow v_1 = -\frac{11}{13}u$$

$$\therefore \frac{\Delta E}{E} = p_c = \frac{\frac{1}{2}mu^2 - \frac{1}{2}m\left(\frac{11}{13}u\right)^2}{\frac{1}{2}mu^2} = \frac{48}{169} = 0.28$$

14. Answer (2)

$$\Delta E_1 = \frac{1}{2}\mu v_{\text{rel}}^2$$

$$= \frac{1}{2}\frac{m}{2}v^2 = \frac{1}{4}mv^2$$

Velocity after collision = $\frac{v}{2}$

$$\Delta E_2 = \frac{1}{2}\left(\frac{2m\cdot M}{2m+M}\right)\left(\frac{v}{2}\right)^2$$

$$\Delta E_1 + \Delta E_2 = \frac{5}{6}\left(\frac{1}{2}mv^2\right)$$

$$\Rightarrow \quad \frac{1}{2}\frac{m}{2}v^2 + \left(\frac{1}{2}\right)\frac{m}{2}v^2\cdot\frac{M}{2m+M} = \frac{5}{6}\left(\frac{1}{2}mv^2\right)$$

$$\Rightarrow \quad 1+\frac{M}{2m+M} = \frac{10}{6} = \frac{5}{3}$$

$$\Rightarrow \quad \frac{M}{m} = 4$$

15. Answer (4)

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$\omega = \sqrt{\frac{k}{m}}$$

$v_{max} = A.\omega$

$\because\ F = kA,\ A = \frac{F}{k}$

$$v_{max} = \frac{F}{k}\cdot\sqrt{\frac{k}{m}}$$

$$\Rightarrow \quad v_{max} = \frac{F}{\sqrt{km}}$$

16. Answer (2)

$$V = \frac{dx}{dt} = 6t$$

$V(t = 0) = 0$

$V(t = 5\text{ s}) = 30$ m/s

$$\Delta \text{KE} = \frac{1}{2}2\times 30^2 = 900\text{ J}$$

17. Answer (1)

$$N - mg = \frac{mg}{2}$$

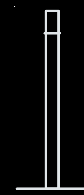
$$N = \frac{3mg}{2}$$

$$S = \frac{1}{2}\left(\frac{g}{2}\right)t^2$$

$$w = \frac{3mg}{2}\times\frac{g}{4}t^2$$

$$w = \frac{3mg^2}{8}t^2$$

18. Answer (2)


O

$$100 - \frac{1}{2}10.t^2 = 100t - 5t^2$$

$\Rightarrow\ t = 1$ s

Conservation of momentum

$\Rightarrow\ 90 \times 0{\cdot}02 - 10 \times 0{\cdot}03 = v \times 0{\cdot}05$

$$\Rightarrow\ v = \frac{1.8-0.3}{0\cdot 05}$$

$$= \frac{1.5}{0\cdot 05} = \frac{150}{5} = 30\text{ m/s}$$

$$s_2 = \frac{30^2}{2\times 10} = \frac{30\times 30}{2\times 10} = 45\text{ m}$$

$\Rightarrow$ Maximum height above the building

= 45 – 5 = 40 m

19. Answer (1)

$$\Delta W = \text{KE}_f - KE_i = \left(3\hat{i} - 12\hat{j}\right)\cdot 4\hat{i}$$

$\Rightarrow\ \text{KE}_f = 12 + \text{KE}_{in} = 12 + 3 = 15$ J

20. Answer (3)

Initial compression = $\frac{3\times 10}{k}$, since spring constant is high. So initial compression is low.

Let v_1 be velocity after collision.

$4v_1 = v_0$

$$v_0 = \sqrt{2g\times 100}$$

$$\frac{1}{2}\times 4\times v_1^2 = \frac{1}{2}kx^2$$

x = 2 cm

21. Answer (1)

$u = \omega\theta_0$

$v = \omega\theta_1$

$\Rightarrow \quad \frac{u}{v} = \frac{\theta_0}{\theta_1}$

Now, $v = \frac{M - m}{M + m} \times u$

$\Rightarrow \quad \frac{M + m}{M - m} = \frac{u}{v} = \frac{\theta_0}{\theta_1}$

$\Rightarrow \quad \frac{M}{m} = \frac{\theta_0 + \theta_1}{\theta_0 - \theta_1}$

$\Rightarrow \quad M = m\left(\frac{\theta_0 + \theta_1}{\theta_0 - \theta_1}\right)$

22. Answer (4)

Area under F–x graph

$\Delta K.E = W = \frac{1}{2} \times (3+2) \times (3-2) + 2 \times 2$

$= 2.5 + 4$

$= 6.5$ J

23. Answer (2)

$m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$

$m_1v_1 + 0.5m_1v_2 = 0.5m_1v_1 + 0.5m_1v_4$

$v_1 = v_4 - v_2$

24. Answer (3)

$m_1 = \frac{M}{n}$

$U_i = \frac{-M}{n} \times g \frac{L}{2n}$

$W = \frac{MgL}{2n^2}$

25. Answer (4)

$2V = \frac{2V}{4} + m_2V_2$

$V = V_2 - \frac{V}{4}$

$\frac{3V}{2} = m_2\left(V + \frac{V}{4}\right)$

$m_2 = \frac{6}{5}$ kg

26. Answer (2)

$mv = (4m + m)v'$

$\therefore$ Common speed $v' = \frac{v}{5}$

$mgh + \frac{1}{2}5m \cdot \frac{v^2}{25} = \frac{1}{2}mv^2$

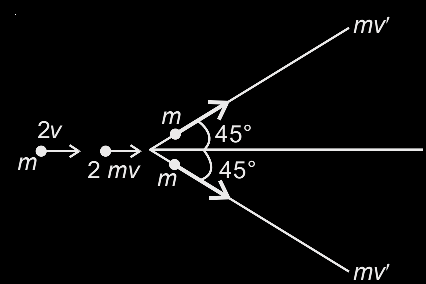
$\Rightarrow mgh = \frac{1}{2}mv^2\left(1 - \frac{1}{5}\right) = \frac{1}{2}mv^2 \cdot \frac{4}{5}$

$\therefore \quad h = \frac{2mv^2}{5 \times mg} = \frac{2v^2}{5g}$

27. Answer (4)

Initial momentum $\cdot$ $P_i = 2mv + 2mv = 4mv$

Let v' be the speed of I particle



$\therefore \quad 2\frac{mv'}{\sqrt{2}} = 4mv$

$\Rightarrow \quad v' = 2\sqrt{2}\,v$

28. Answer (4)

Apply conservation of linear momentum in X and Y direction for the system then

$M(10\cos30°) + 2M(5\cos45°) = 2M\,(v_1\cos30°) + M(v_2\cos45°)$

$5\sqrt{3} + 5\sqrt{2} = \sqrt{3}\,v_1 + \frac{v_2}{\sqrt{2}}$ ...(1)

Also

$2M(5\sin45°) - M(10\sin30°) = 2Mv_1\sin30° - Mv_2\sin45°$

$5\sqrt{2} - 5 = v_1 - \frac{v_2}{\sqrt{2}}$ ...(2)

Solving equation (1 and 2)

$(\sqrt{3} + 1)v_1 = 5\sqrt{3} + 10\sqrt{2} - 5 \quad \Rightarrow \quad v_1 = 6.5$ m/s

$v_2 = 6.3$ m/s

29. Answer (2)

$F_{total} = Mg + \text{friction}$

$= 2000 \times 10 + 4000$

$= 20{,}000 + 4000 = 24000\text{ N}$

$P = F \times v$

$60 \times 746 = 24000 \times v$

$\Rightarrow v = 1.86\text{ m/s} \approx 1.9\text{ m/s}$

30. Answer (2)

$F = (10\,m + M)g + f$

where, $m = 68$ kg, $M = 920$ kg, $f = 6000$ N

$\Rightarrow F = 22000$ N

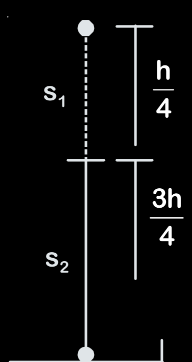
$\Rightarrow P = FV = 22000 \times 3 = 66000$ W

31. Answer (4)

Time of collision

$$\Rightarrow t_0 = \frac{h}{\sqrt{2gh}} = \sqrt{\frac{h}{2g}}$$

$$\therefore s_1 = \frac{1}{2}gt_0^2 = \frac{1}{2}g\cdot\frac{h}{2g} = \frac{h}{4}$$



$$\therefore s_2 = \frac{3h}{4}$$

Speed of (A) just before collision $v_1 \downarrow = gt_0 = \sqrt{\frac{gh}{2}}$

And speed of (B) just before collision $v_2 \uparrow$

$$= \sqrt{2gh} - \sqrt{\frac{gh}{2}}$$

After collision velocity of centres of mass

$$V_{cm} = \frac{m\left(\sqrt{2gh} - \sqrt{\frac{gh}{2}}\right) - m\sqrt{\frac{gh}{2}}}{2m} = 0$$

So from there, time of fall 't'

$$\Rightarrow \frac{3h}{4} = \frac{1}{2}gt^2$$

$$\Rightarrow t = \sqrt{\frac{3}{2}\frac{h}{g}}$$

32. Answer (2)

$$W = \int dW = \int(-x\hat{i} + y\hat{j})\cdot(dx\hat{i} + dy\hat{j})$$

$$W = -\int_1^0 x\,dx + \int_0^1 y\,dy = \frac{1}{2} + \frac{1}{2} = 1\text{ J}$$

33. Answer (3)

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

$$\Rightarrow mu\hat{i} + m\left(\frac{u}{2}\hat{i} + \frac{u}{2}\hat{j}\right) = (m+m)(v_1\hat{i} + v_2\hat{j})$$

Compare both side

$$\Rightarrow v_1 = \frac{3u}{4}, v_2 = \frac{u}{4}$$

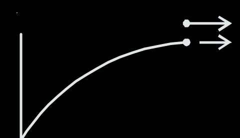
$\Delta KE = K_i - K_f$

$$= \frac{1}{2}mu^2 + \frac{1}{2}m\left(\frac{u}{2}\sqrt{2}\right)^2 - \frac{1}{2}(2m)\left(\frac{9u^2}{16} + \frac{u^2}{16}\right)$$

$$= \frac{mu^2}{8}$$

34. Answer (3)

$2mv_x = mu + mu\cos 60°$



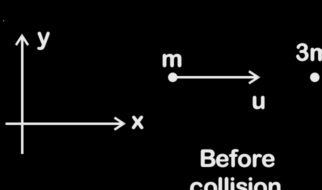
$$v_x = \frac{3u}{4}$$

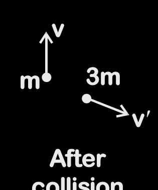
Horizontal range after collision

$$= \frac{3u}{4}\times\sqrt{\frac{2H}{g}}$$

$$= \frac{3\sqrt{3}u^2}{8g}$$

35. Answer (4)





Conservation of linear momentum

$$3\,m\vec{v}' = mu\hat{i} - mv\hat{j}$$

for elastic collision

$$\frac{1}{2}3mv'^2 + \frac{1}{2}mv^2 = \frac{1}{2}mu^2$$

Elliminating v′ gives

$$v = \frac{u}{\sqrt{2}}$$

36. Answer (4)

Velocity of block after collision

$$= \frac{0.1\times 20}{1.9+0.1} = 1\text{ m/s}$$

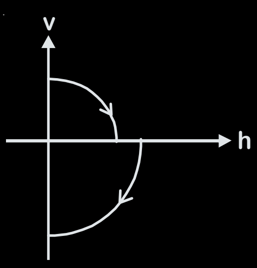
Kinetic energy just before striking the floor

$$= \frac{1}{2}\times 2\times 1^2 + 2\times 10\times 1$$

= 21 J

37. Answer (2)

At H = h, v = 0



at h = 0, $v = \sqrt{2gh}$

also a = –g, throughout this motion

38. Answer (4)

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

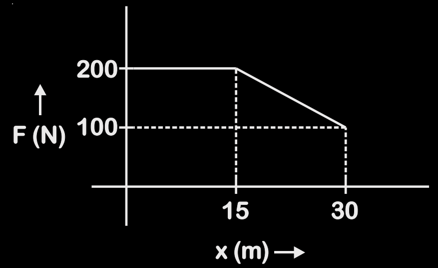
$$\Rightarrow \quad mv = (16\,m)\,v_0 \quad \Rightarrow \quad v_0 = \frac{v}{16}$$

$$(\Delta KE)_{Loss} = \frac{1}{2}mv^2 - \frac{1}{2}(16\,m)\left(\frac{v}{16}\right)^2$$

$$\Rightarrow \quad \%\text{ Loss} = \frac{(\Delta KE)_{Loss}}{\frac{1}{2}mv^2}\times 100 = \left(1-\frac{1}{16}\right)\times 100$$

$$\simeq 94\%$$

39. Answer (3)



Work = Area of F–x curve

$$= 200\times 15 + \frac{1}{2}(200+100)\times 15$$

= 5250 J

40. Answer (3)

$$F = -\frac{dU}{dr}$$

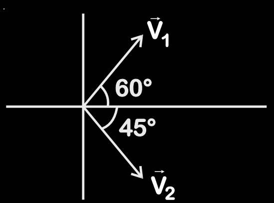
$$= -\left[\frac{6A}{r^7} - \frac{12B}{r^{13}}\right]$$

F = 0

$$\Rightarrow r = \left(\frac{2B}{A}\right)^{1/6}$$

$$U\left(at\ r = \left(\frac{2B}{A}\right)^{1/6}\right) = -\frac{A^2}{4B}$$

41. Answer (4)



m_2 = m and m_1 = 2m

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

$$\Rightarrow \quad 2m\left(\sqrt{3}\hat{i} + \hat{j}\right) = 2m\left(\hat{i} + \sqrt{3}\hat{j}\right) + m\vec{V}_2$$

$$\Rightarrow \quad \vec{V}_2 = \left(2\sqrt{3}-2\right)\hat{i} - \hat{j}\left(2\sqrt{3}-2\right)$$

$$\vec{V}_1 = \left(\hat{i} + \sqrt{3}\hat{j}\right)$$

$\Rightarrow$ Angle θ = 105°

42. Answer (10.00)

$$KE = mg\Delta h$$

$$= 1\times 10\times 1 = 10\text{ J}$$

43. Answer (01)

By conservation of momentum

$\vec{u}_A + \vec{u}_B = \vec{v}_A + \vec{v}_B$ (Masses are equal)

$\therefore \quad \vec{v}_B = (3\hat{i} + 5\hat{j}) - (4\hat{i} + 4\hat{j}) = \hat{j} - \hat{i}$

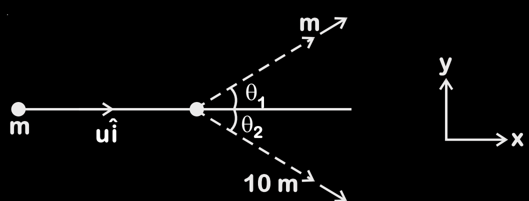
$\therefore \quad \text{KE}_B = \frac{1}{2} m v_B^2$

$= \frac{1}{2} \times 0.1 \times (\sqrt{2})^2$

$= \frac{1}{10}\text{J} = \frac{x}{10}\text{J}$

$\therefore \quad x = 1$

44. Answer (10)



Since energy of m reduced by half $\therefore \; u_1 = \frac{u}{\sqrt{2}}$

and $\frac{1}{2} \times 10\, m \cdot v_1^2 = \frac{1}{2} m \frac{u^2}{2} \Rightarrow v_1 = \frac{u}{\sqrt{20}}$

Now, momentum in y direction will remain conserved

$\therefore \quad mu_1 \sin\theta_1 = 10mv_1 \sin\theta_2$

$\Rightarrow \quad \frac{u}{\sqrt{2}} \sin\theta_1 = 10 \frac{u}{\sqrt{20}} \sin\theta_2$

$\Rightarrow \quad \sin\theta_1 = \sqrt{10}\, \sin\theta_2$

45. Answer (150.00)

Initial velocity $V_0^2 = 2gh$

$\Rightarrow \quad V_0 = \sqrt{2 \times 10 \times 20} = 20 \text{ m/s}$

Now work done by the machine.

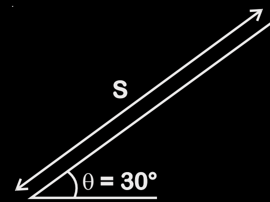
$F \cdot x = \Delta KE = \frac{1}{2} m v_0^2$

$F \times \frac{2}{10} = \frac{1}{2} \times \frac{15}{100} \times 400$

$\Rightarrow \quad F = 150$

46. Answer (346)

For upward motion



$\frac{1}{2} m v_0^2 = \left(mg\frac{S}{2} + \mu mg \frac{\sqrt{3}}{2} S \right)$ ...(i)

$\frac{1}{2} \frac{m v_0^2}{4} = \left(mg\frac{S}{2} - \mu mg \frac{\sqrt{3}}{2} . S \right)$ ...(ii)

for downward

$4 = \frac{(1 + \mu\sqrt{3})}{(1 - \mu\sqrt{3})}$

$\Rightarrow \quad 4 - 4\mu\sqrt{3} = 1 + \mu\sqrt{3}$

$\Rightarrow \quad 3 = 5\mu\sqrt{3} \;\therefore\; \mu = \frac{\sqrt{3}}{5} \approx \frac{346.41}{1000}$

$I = 346$

47. Answer (18.00)

$pt = \frac{1}{2} m v^2$

$\Rightarrow \quad v = \sqrt{\frac{2pt}{m}}$

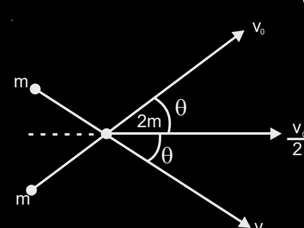
$\Rightarrow \quad \frac{ds}{dt} = \sqrt{\frac{2pt}{m}}$

$\Rightarrow \quad \int_0^s ds = \int_0^t \sqrt{\frac{2pt}{m}}\, dt$

$\Rightarrow \quad s = \left(\sqrt{\frac{2p}{m}} \right) \left(\frac{2t^{\frac{3}{2}}}{3} \right) = (1) \times (2) \times \frac{27}{3} = 18$

48. Answer (120.00)

$mv_0 \times \cos\theta \times 2 = \mathbf{2m} \times \left(\frac{\mathbf{V_0}}{\mathbf{2}} \right)$

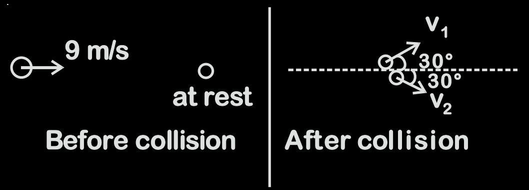


$\Rightarrow \quad \cos\theta = \frac{1}{2}$

$\Rightarrow \quad \theta = 60°$

$\therefore \quad 2\theta = 120°$

49. Answer (1)



Using conservation of linear momentum

In x-direction —

$mv_1 \cos30° + mv_2 \cos30° = m.9$

In y-direction —

$mv_1 \sin30° - mv_2 \sin30° = 0$

$$\frac{v_1}{v_2} = 1$$

50. Answer (1)

Loss in KE = work against damping

$$\Rightarrow \frac{1}{2}mv_0^2 = \int_{x=0}^{x} \alpha x^2\,dx$$

$$\Rightarrow \frac{1}{2}mv_0^2 = \frac{\alpha x^3}{3}$$

$$\Rightarrow x = \left(\frac{3mv_0^2}{2\alpha}\right)^{\frac{1}{3}}$$

51. Answer (2)

$$k = \frac{P^2}{2m}$$

$$\frac{K_A}{k_B} = \frac{m_B}{m_A} = \frac{2}{1}$$

52. Answer (5)

$$\frac{T_{max}}{T_{min}} = 5$$

$$T_{max} - T_{min} = 6\text{ mg}$$

$$T_{min} = \frac{3}{2}\text{mg}$$

$$T_{min} + mg = \frac{mv^2}{l}$$

$$\Rightarrow v = \sqrt{\frac{5}{2}gl} = 5\text{ m/s}$$

53. Answer (1)

$$U = \frac{\alpha}{r^{10}} - \frac{\beta}{r^5} - 3$$

$$\frac{dU}{dr} = -\frac{10\alpha}{r^{11}} + \frac{5\beta}{r^6}$$

for equilibrium $\frac{dU}{dr} = 0$

$$r = \left(\frac{2\alpha}{\beta}\right)^{\frac{1}{5}}$$

54. Answer (1)

$$P = \sqrt{2mk}$$

$$\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{4}{16}} = \frac{1}{2}$$

55. Answer (1)

$$V_2 = \frac{2M}{M+m} \times u$$

$\because$ *m* << M_1

$$\Rightarrow V_2 \approx \frac{2M}{M} \times u = 2u$$

56. Answer (2)

Let initial momentum be p.

$$\frac{p^2}{2(m+M)} = (m+M)gH$$

$$p = (m+M)\sqrt{2gH}$$

$$= 6 \times \sqrt{\frac{2 \times 9.8 \times 9.8}{100}}$$

$$p = 6\sqrt{2} \times 0.98$$

$$6\sqrt{2} \times 0.98 = 0.01\,V$$

$$V = 600 \times 0.98\sqrt{2}$$

57. Answer (1)

$$\frac{K_i}{K_f} = 20$$

$$\frac{V_2}{V_0} = \frac{1}{\sqrt{20}}$$

$$V_2 = \sqrt{20}\text{ m/s}$$

58. Answer (3)

$h = h_0 e^2$

$$\Rightarrow \frac{81}{100} = e^2 \quad \Rightarrow e = 0.9$$

$$S_{total} = h_0 + 2h_1 + 2h_2 + 2h_3 + ...$$

$$= h_0 [1 + 2(e^2 + e^4 + e^6 + ...)]$$

$$= h_0\left[1+2\times e^2\times\left(\frac{1}{1-e^2}\right) = h_0\left(\frac{1+e^2}{1-e^2}\right)\right]$$

$$T_{total} = \sqrt{\frac{2h_0}{g}}\,[1+2\times e+2e^2+...]$$

$$= \sqrt{\frac{2\times 5}{10}}\left[1+2e\left(\frac{1}{1-e}\right) = 1\times\left(\frac{1+e}{1-e}\right)\right]$$

$$\therefore V_{av} = \frac{5\times(1+0.9^2)}{(1-0.9^2)}\times\left(\frac{1-0.9}{1+0.9}\right) = 2.50 \text{ m/s}$$

59. Answer (1)

P = constant = k(say)

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

$$\Rightarrow v = \sqrt{\frac{2k}{m}}t^{1/2}$$

$$\Rightarrow \frac{ds}{dt} = \sqrt{\frac{2k}{m}}t^{1/2}$$

$$\Rightarrow \int_0^s ds = \sqrt{\frac{2k}{m}}\int_0^t t^{1/2}dt$$

$s \propto t^{3/2}$

60. Answer (10)

$$F_{avg} = \frac{\Delta K.E.}{\text{distance}} = \frac{\frac{1}{2}mv^2}{s}$$

$$= \frac{\frac{1}{2}\times 0.1\times 100}{0.5} = 10 \text{ N}$$

61. Answer (20)

Velocity of 10 kg ball = $v_{10} = 10\sqrt{3}\hat{i}$

initial total momentum of system = $10\times 10\sqrt{3}\hat{i}$

Final total momentum of system

$$= 10\times 10\hat{j} + 10\times x(\cos 30°\hat{i} - \sin 30°\hat{j})$$

Now by conservation of momentum

$$10\times 10\sqrt{3}\hat{i} = 10\times 10\hat{j} + 10\times x\left(\frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j}\right)$$

$\Rightarrow x = 20$

62. Answer (10)

By Energy Conservation

$T.E_A = T.E_B$

$$mg\,(10) + 0 = mg\,(5) + \frac{1}{2}mv^2$$

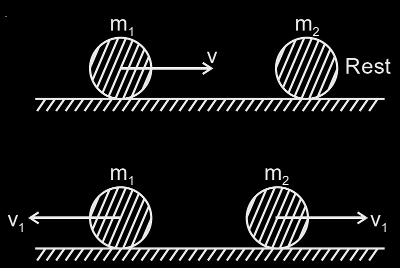
$$\Rightarrow v = \sqrt{2\times g\times 5} = 10 \text{ m/s}$$

$\Rightarrow x = 10$

63. Answer (2)

Assuming e = 1

$m_1 v = (m_2 - m_1)v_1$



$$\Rightarrow v_1 = \frac{m_1 v}{(m_2 - m_1)} \qquad ...(i)$$

also $2v_1 = v$

$$\Rightarrow v_1 = \frac{v}{2}$$

$$\Rightarrow \frac{1}{2} = \frac{m_1}{m_2 - m_1}$$

$$\Rightarrow \frac{m_2}{m_1} = 3$$

64. Answer (6)

$$\frac{1}{2}\times 4\times(10)^2 = \frac{1}{2}\times 100\times(\Delta x)^2$$

$\Rightarrow \Delta x = 2$ m

$\Rightarrow x = 8 - 2 = 6$ m

65. Answer (1)

$$\frac{1}{2}mv_0^2 = \frac{1}{2}kx_0^2$$

$d = v_0T$

$$= x_0\sqrt{\frac{k}{m}} \cdot \sqrt{\frac{2h}{g}}$$

$$= 0.05\sqrt{\frac{100}{0.1}}\sqrt{\frac{2\times 2}{10}}$$

= 1.0 m

66. Answer (2)

Momentum, $P = \sqrt{2km}$

$$\% \text{ change in } P = \frac{P_2 - P_1}{P_1} \times 100\%$$

$$= \frac{\sqrt{2k_2m} - \sqrt{2k_1m}}{\sqrt{2k_1m}} \times 100\%$$

$$= \frac{\sqrt{k_2} - \sqrt{k_1}}{\sqrt{k_1}} \times 100\%$$

$$= \left(\sqrt{\frac{k_2}{k_1}} - 1\right) \times 100\%$$

$$= \left(\sqrt{\frac{4k_1}{k_1}} - 1\right) \times 100\%$$

= 100%

67. Answer (3)

P = C

So. K.E. = Pt

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

$$\Rightarrow v = \sqrt{\frac{2P}{m}}\sqrt{t}$$

$$\Rightarrow v = C\sqrt{t}$$

$$\frac{ds}{dt} = C\sqrt{t}$$

$$\int ds = \int C\sqrt{t}\, dt$$

Distance = C $t^{3/2}$

68. Answer (3)

W = –N × Δx

$$= -80 \times 9.8 \times \frac{80}{100}$$

= –627.2 J

69. Answer (450)

$$W = \int \vec{F} \cdot d\vec{r}$$

$$= \int_0^{10} (5y + 20)dy$$

= 450 J

70. Answer (4)

After 1st collision

$$V_B = \frac{2V_0}{3}$$

After inelastic collision

$$V_C = \frac{V_B}{2}$$

71. Answer (20)

$$\frac{1}{2}y(\text{strain})^2 \times \text{volume} = \frac{1}{2}mv^2$$

$$\frac{1}{2}\times 0.5\times 10^9 \times 16\times 10^{-2} \times 10^{-7} = \frac{1}{2}\times 20\times 10^{-3} \times v^2$$

$\Rightarrow$ $v^2 = 400$

v = 20 m/s

72. Answer (1)

At $x < x_1$, KE = 0

$\Rightarrow$ Particle is at rest

73. Answer (2)

Power = P

So, K.E = Pt

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

$$v^2 = \frac{2P}{m}t$$

$$v = \sqrt{\frac{2P}{m}}t^{\frac{1}{2}}$$

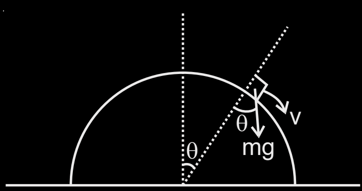
$$dx = \sqrt{\frac{2P}{m}}t^{\frac{1}{2}}dt$$

$$\int dx = \sqrt{\frac{2P}{m}}\int_0^t t^{\frac{1}{2}}dt$$

$$x = \sqrt{\frac{2P}{m}}\,\frac{t^{3/2}}{3/2}$$

$$x = \left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{3/2}$$

74. Answer (2)



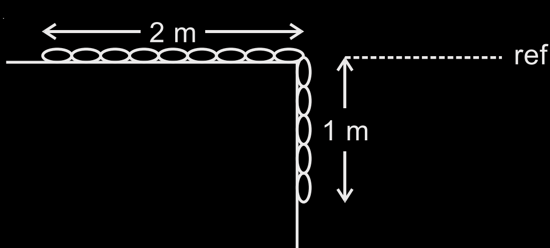
$$mg\cos\theta = \frac{mv^2}{R}$$

$$\frac{1}{2}mv^2 = mgR(1-\cos\theta)$$

On solving $\cos\theta = \frac{2}{3}$

$$h = \frac{2R}{3} = 2\text{ m}$$

75. Answer (40)



$$\text{P.E.}_{\text{initial}} = -\frac{m}{3}\times\frac{\ell}{3}\times\frac{1}{2}g = \frac{-mg\ell}{18}$$

$$\text{P.E.}_{\text{final}} = -m\frac{\ell}{2}g = -\frac{mg\ell}{2}$$

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

$$\Rightarrow \frac{1}{2}mv^2 = \frac{4}{9}\times m\times\ell\times g$$

$$\Rightarrow \frac{1}{2}mv^2 = 40\text{ J}$$

76. Answer (2)

$$F_1 d\cos 45^\circ = F_2 d\cos 60^\circ$$

$$\Rightarrow \frac{F_2}{F_1} = \sqrt{2}$$

$$\frac{F_1}{F_2} = \frac{1}{\sqrt{2}}$$

77. Answer (2)

$$\left|G.P.E|_{\text{system}}\right| = \frac{Gm^2}{d\sqrt{2}} + \frac{G(M-m)^2}{d\sqrt{2}} + \frac{4Gm(M-m)}{d}$$

Differentiation with respect to *m* should be equal to zero.

$$\Rightarrow\ 2m - 2(M-m) + 4\sqrt{2}(M-m) - 4\sqrt{2}(m) = 0$$

$$\Rightarrow\ m\left(2-4\sqrt{2}\right) + (M-m)(4\sqrt{2}-2) = 0$$

$$\Rightarrow\ m = \frac{M}{2}$$

78. Answer (4)

$2p\cos\theta = p_0$ ...(i)

Now, $\frac{p_0^2}{2M} = p^2\left(\frac{1}{2m}+\frac{1}{2M}\right)$ ...(ii)

$$\Rightarrow (2\cos\theta)^2 = \frac{M}{m}+1$$

$$\Rightarrow \left(\frac{M}{m}\right)_{\max} = 4-1 = 3$$

79. Answer (4)

$$(m)\,40 = \left(\frac{m}{3}\right)\times 60 + \left(\frac{2m}{3}\right)V$$

$$\Rightarrow \frac{2V}{3} = 20 \quad\Rightarrow\quad V = 30\text{ m/s}$$

$$k_f = \frac{1}{2}\left(\frac{m}{3}\right) \times (60)^2 + \frac{1}{2}\left(\frac{2m}{3}\right)(30)^2$$

$$\frac{\Delta k}{k} = \frac{(k_f - k_i)}{k_i} = \frac{1}{8}$$

80. Answer (4)

K.E. of particle $= \frac{1}{2} m \left(0.8\sqrt{gh}\right)^2$

$$= \frac{0.64}{2} \text{ mgh}$$

= 0.32 mgh

So work done by air friction = 0.32 mg – work done by mg = – 0.68 mgh

81. Answer (16)

$$-\frac{1}{2} \cdot kx^2 + W_f = 0 - \frac{1}{2} Mv^2$$

$$\frac{1}{2} k(1)^2 = (1 - 0.9)\frac{1}{2} Mv^2$$

$k = 0.1 \times 40000 \times (20)^2$

$= 16 \times 10^5$ N/m

82. Answer (3)

$$W = \int \vec{F} \cdot d\vec{r}$$

$$= \int_1^2 4x\,dx + \int_2^3 3y^2 dy$$

$$= [2x^2]_1^2 + \left[y^3\right]_2^3$$

= 2 × 3 + (27 – 8)

= 25 J

83. Answer (120)

$$mg\left(h + \frac{h}{2}\right) = \frac{1}{2} k \left(\frac{h}{2}\right)^2$$

$$\Rightarrow 0.1 \times 10 \times (0.15) = \frac{1}{2} k (0.05)^2$$

k = 120 N/m

84. Answer (600)

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

$$\Rightarrow \frac{3}{8} mv^2 = \frac{1}{2} kx^2$$

$$\Rightarrow k = \frac{3}{4} \times \frac{1}{2} \times \frac{144}{9} \times 100$$

= 600

$\Rightarrow$ 600

85. Answer (1)

At topmost position,

$v = 0$

$\Rightarrow$ momentum = 0

86. Answer (3)

$$N = mg\sin\alpha + \frac{mv^2}{R}$$

and, $v^2 = 2g \times R\sin\alpha$

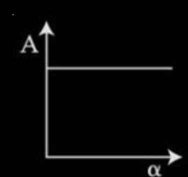
$\therefore$ $N = mg\sin\alpha + m \times (2g\sin\alpha) = 3mg\sin\alpha$

$$\therefore \text{ ratio, } A = \frac{\frac{mv^2}{R}}{N}$$

$$= \frac{2mg\sin\alpha}{3mg\sin\alpha}$$

$$= \frac{2}{3}$$

$\therefore$



87. Answer (10)

$v_{bob} = \sqrt{5gl} = \sqrt{5 \times 10 \times 2}$ = 10 m/s

Conserving momentum:

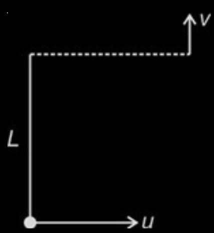
$75 \times v = 75 \times \frac{v}{3} + 50 \times 10$

$50v = 50 \times 10$

v = 10 m/s

88. Answer (2)

$\vec{v} = \sqrt{u^2 - 2gL}\,\hat{j}$



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

$\therefore \quad |\vec{v} - \vec{u}| = \sqrt{(u^2 - 2gL) + u^2}$

$= \sqrt{2u^2 - 2gL}$

$\therefore \quad x = 2$

89. Answer (3)

$a_r = k^2rt^2 = \dfrac{v^2}{r}$

$\Rightarrow \quad v^2 = k^2r^2t^2$ or $v = krt$

and $\dfrac{d|v|}{dt} = kr$

$\Rightarrow \quad a_t = kr$

$\Rightarrow \quad |\bar{F} \cdot \bar{v}| = (mkr)(krt)$

$= mk^2r^2t$ = power delivered

90. Answer (5)

$\dfrac{1}{2}mv^2 = mgl(1 - \cos\theta)$

$\Rightarrow \quad v = \sqrt{2gl(1 - \cos\theta)}$

$= \sqrt{2 \times 10 \times 2.5 \times \dfrac{1}{2}}$

= 5 m/s

91. Answer (3)

$F = -12x$

$mv\dfrac{dv}{dx} = -12x$

$\int_4^v vdv = -6\int_{0.5}^{1.5} xdx \qquad (m = 2 \text{ kg})$

$\dfrac{v^2 - 16}{2} = -6\left[\dfrac{1.5^2 - 0.5^2}{2}\right]$

$\dfrac{v^2 - 16}{2} = -6$

$v = 2$ m/sec

92. Answer (2)

Total gravitational PE of water per second $= \dfrac{mgh}{T}$

$= \dfrac{9 \times 10^4 \times 10 \times 40}{3600} = 10^4$ J/sec

50% of this energy can be converted into electrical energy so total electrical energy $= \dfrac{10^4}{2} = 5000$ W

So total bulbs lit can be $= \dfrac{5000 \text{ W}}{100 \text{ W}}$

= 50 bulbs

93. Answer (4)

$W_{total} = \Delta K$

$= \dfrac{1}{2}\left(\dfrac{1}{2}\right)\left[\{b(4)^{5/2}\}^2 - 0\right]$

$= \dfrac{b^2}{4} \times 4^5$

$\Rightarrow \quad W_{total} = 16$ J

94. Answer (4)

Loss in potential energy = gain in kinetic energy

$-(mg(y - y_0) - mgy) = \text{KE} - 0$

$\Rightarrow \quad \text{KE} = mgy_0$

95. Answer (2)

$v = 3x^2 + 4$

at $x = 0$, $v_1 = 4$ m/s

$x = 2$, $v_2 = 16$ m/s

$\Rightarrow$ Work done = Δ kinetic energy

$= \dfrac{1}{2} \times m\left(v_2^2 - v_1^2\right)$

$= \dfrac{1}{4}(256 - 16)$

= 60 J

96. Answer (2)

Change in momentum of one ball

$= 2 \times (0.05)(10)$ kg m/s

$= 1$ kg m/s

$\Rightarrow \quad F_{avg} = \frac{1}{\Delta t} = \frac{1}{0.005}$ N

$= 200$ N

97. Answer (2)

Loss in $KE = \frac{1}{2} \times \frac{m_1 m_2}{m_1 + m_2} \times v^2$

$= \frac{1}{2} \times \frac{9.8 \times 0.2}{10} \times (10)^2$

$= 9.8$ J

98. Answer (2)

$\because$ Loss in KE = Gain in spring energy

$\Rightarrow \quad \frac{1}{2} m v^2 \times 2 = \frac{1}{2} k x_m^2$

$\Rightarrow \quad 2 \times \frac{1}{4} \times v^2 = 2 \times x_m^2$

$\Rightarrow \quad x_m = \sqrt{\frac{v^2}{4}} = \frac{v}{2}$

99. Answer (4)

$\frac{dm}{dt} = 0.5$ kg/s

$v = 5$ m/s

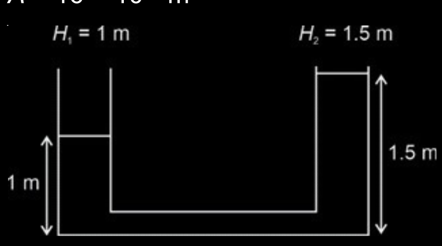
$F = \frac{v dm}{dt} = 2.5$ kg m/s^2

$P = \bar{F} \cdot \bar{v} = (2.5)(5)$ W

$= 12.5$ W

100. Answer (2)

$A = 16 \times 10^{-4}$ m^2



$E_{in} = m_1 g \frac{H_1}{2} + m_2 g \frac{H_2}{2}$

$= \rho g \frac{A}{2}\left(H_1^2 + H_2^2\right) = \rho g \frac{A}{2}\left(1^2 + 1.5^2\right)$

$E_{fin} = \rho g \frac{A}{2}(2H^2) = \rho g \frac{A}{2}(2 \times 1.25^2)$

$W = \rho g \frac{A}{2}(3.25 - 3.125)$

$= 1$ J

101. Answer (2)

ΔP = impulse = same since acceleration is different force acting will be different.

102. Answer (24)

ΔKE = W_{all}

So $\frac{E}{4} - E = -\frac{1}{2} \text{K} \times (0.25)^2$

$\frac{3E}{4} = \frac{1}{2} \text{K} \times \frac{1}{16}$

$K = 24E$

103. Answer (1)

$\frac{1}{2} m x^2 = 90$

$\Rightarrow \quad \frac{1}{2} \times 0.2 \times x^2 = 90$,

$x^2 = 900$

$x = 30$ m/s

$\frac{1}{2} m v^2 = 40 \Rightarrow v = \frac{2}{3} \times 30 = 20$ m/s

$20 = 30 - a \times 1 \Rightarrow a = -10$ m/s^2

$0 - x^2 = 2as$

$s = \frac{x^2}{-2a} = \frac{30 \times 30}{2 \times 10}$

$= 45$ m

104. Answer (3)

$S = 4$ cm

$v'_4 = \frac{v}{3}$, a = constant

$v_{4+x} = 0$

$\left(v^2 - \frac{v^2}{a}\right) = 2a(4)$

$(v^2 - 0) = 2a(4 + x)$

$\frac{4}{4+x} = \frac{8}{9}$

$\Rightarrow$ $x = 0.5$ m

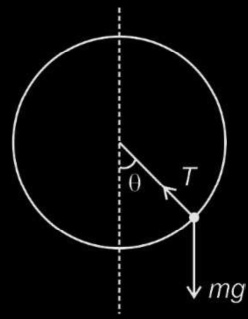
105. Answer (1)

$W_a = 0$, $W_b = +\text{ve}$, $W_c = +\text{ve} > W_b$, $W_d = -\text{ve}$

$\Rightarrow$ $W_c > W_b > W_a > W_d$

$\Rightarrow$ $W_3 > W_2 > W_1 > W_4$

106. Answer (2)



At any θ : $T - mg\cos\theta = \frac{mv^2}{R}$

$\Rightarrow$ $T = mg\cos\theta + \frac{mv^2}{R}$

Since v is constant,

$\Rightarrow$ T will be minimum when $\cos\theta$ is minimum.

$\Rightarrow$ $\theta = 180°$ corresponds to T_{minimum}.

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