Class 11 Physics Chapter 5: Work, Energy, and Power

Multiple Choice Questions I

6.1. Magnetic Forces and Kinetic Energy

Question: An electron and a proton are moving under the influence of mutual forces. In calculating the change in the kinetic energy of the system during motion, one ignores the magnetic force of one on another. This is because:

a) the two magnetic forces are equal and opposite, so they produce no net effect
b) the magnetic forces do no work on each particle
c) the magnetic forces do equal and opposite work on each particle
d) the magnetic forces are necessarily negligible

Answer: b) the magnetic forces do no work on each particle

Explanation: Magnetic forces are always perpendicular to the velocity of charged particles. Since work $W = \vec{F} \cdot \vec{s} = Fs \cos \theta$, and $\theta = 90°$, the work done by magnetic forces is zero ($\cos 90° = 0$).

6.2. Coulomb Force and Work Done

Question: A proton is kept at rest. A positively charged particle is released from rest at a distance d in its field. Consider two experiments; one in which the charged particle is also a proton and in another, a positron. In the same time t, the work done on the two moving charged particles is:

a) same as the same force law is involved in the two experiments
b) less for the case of a positron, as the positron moves away more rapidly and the force on it weakens
c) more for the case of a positron, as the positron moves away a larger distance
d) same as the work done by charged particle on the stationary proton

Answer: c) more for the case of a positron, as the positron moves away a larger distance

Explanation: Since $F = kq_1q_2/r^2$ and $a = F/m$, the positron (much lighter than proton) experiences greater acceleration, travels farther in time t, so $W = \int F \cdot dr$ is greater.

6.3. Normal Force During Standing Up

Question: A man squatting on the ground gets straight up and stands. The force of reaction of ground on the man during the process is:

a) constant and equal to mg in magnitude
b) constant and greater than mg in magnitude
c) variable but always greater than mg
d) at first greater than mg, and later becomes equal to mg

Answer: d) at first greater than mg, and later becomes equal to mg

Explanation: Initially, to accelerate upward, $N > mg$ (Newton's second law: $N - mg = ma$, where $a > 0$). Once standing, $N = mg$ for equilibrium.

6.4. Work Done by Cycle on Road

Question: A bicyclist comes to a skidding stop in 10 m. During this process, the force on the bicyclist due to the road is 200 N and is directly opposed to the motion. The work done by the cycle on the road is:

a) +2000 J

b) -200 J

c) zero

d) -20,000 J

Answer: c) zero

Explanation: By Newton's third law, forces are equal and opposite. The cycle doesn't move relative to the road contact point, so no displacement occurs at the contact point, hence W = 0.

6.5. Conservation During Free Fall

Question: A body is falling freely under the action of gravity alone in vacuum. Which of the following quantities remain constant during the fall?

a) kinetic energy

b) potential energy

c) total mechanical energy

d) total linear momentum

Answer: c) total mechanical energy

Explanation: In absence of non-conservative forces, E = KE + PE = constant. As PE decreases, KE increases by equal amount.

6.6. Inelastic Collision Conservation

Question: During inelastic collision between two bodies, which of the following quantities always remain conserved?

a) total kinetic energy

b) total mechanical energy

c) total linear momentum

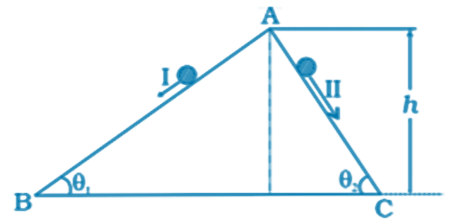
d) speed of each body

Answer: c) total linear momentum

Explanation: Momentum is conserved in all collisions due to Newton's third law: $\Sigma \vec{p}_i = \Sigma \vec{p}f$. Kinetic energy is not conserved in inelastic collisions.

6.7. Inclined Plane Motion

Question: Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from rest, one on each track. Which statement is correct?



a) both stones reach bottom at same time but not with same speed

b) both stones reach bottom with same speed and stone I reaches bottom earlier

c) both stones reach bottom with same speed and stone II reaches bottom earlier

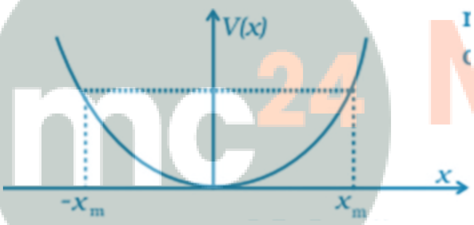
d) both stones reach bottom at different times and with different speeds

Answer: c) both stones reach bottom with same speed and stone II reaches bottom earlier than stone I

Explanation: By conservation of energy: $mgh = \frac{1}{2}mv^2$, so $v = \sqrt{2gh}$ is same for both. However, stone II on steeper track has greater acceleration component along slope, reaching bottom faster.

6.8. Simple Harmonic Motion Energy

Question: The potential energy function for a particle executing linear SHM is given by $V(x) = \frac{1}{2}kx^2$ where k is the force constant. For k = 0.5 N/m, if a particle of total energy E turns back when it reaches $x = \pm x_m$, then which is correct?



a) V = 0, K = E

b) V = E, K = 0

c) V < E, K = 0

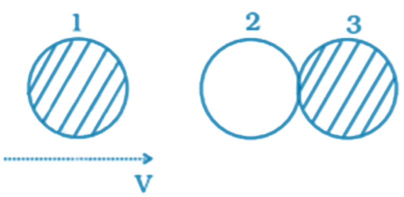
d) V = 0, K < E

Answer: b) V = E, K = 0

Explanation: At turning points, all energy is potential: E = V + K = V + 0 = V. The particle momentarily stops (K = 0) before reversing direction.

6.9. Elastic Collision of Ball Bearings

Question: Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with speed V. If the collision is elastic, which is a possible result?



Answer: b) Ball 1 stops ($v = 0$), Ball 2 moves with $V/2$, Ball 3 moves with V

Explanation: Conservation of momentum: $mV = m(0) + m(V/2) + m(V)$. Conservation of kinetic energy: $\frac{1}{2}mV^2 = 0 + \frac{1}{2}m(V/2)^2 + \frac{1}{2}mV^2$.

6.10. Work-Energy Theorem Application

Question: A body of mass 0.5 kg travels in a straight line with velocity $v = ax^{(3/2)}$ where $a = 5\ m^{(-1/2)}s^{(-1)}$. The work done by the net force during its displacement from $x = 0$ to $x = 2$ m is:

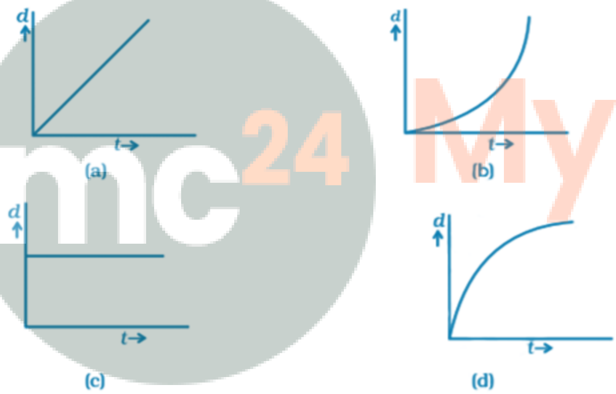
a) 1.5 J
b) 50 J
c) 10 J
d) 100 J

Answer: b) 50 J

Explanation: Using work-energy theorem: $W = \Delta KE = \frac{1}{2}m(v_2^2 - v_1^2)$ At $x = 0$: $v_1 = 0$ At $x = 2$: $v_2 = 5(2)^{(3/2)} = 5(2\sqrt{2}) = 10\sqrt{2}$ m/s $W = \frac{1}{2}(0.5)[(10\sqrt{2})^2 - 0^2] = \frac{1}{4}(200) = 50$ J

6.11. Power and Displacement-Time

Question: A body is moving unidirectionally under the influence of a source of constant power supplying energy. Which diagram correctly shows the displacement-time curve?

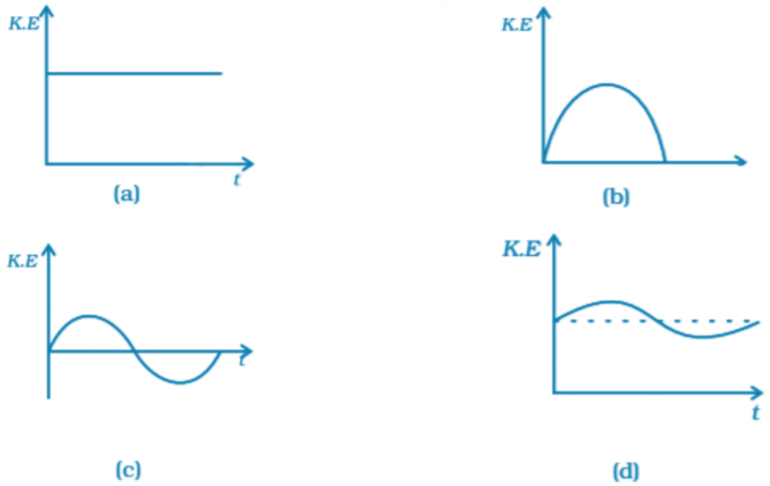


Answer: b) Curved upward (concave up)

Explanation: $P = Fv$ = constant, so as v increases, F decreases. From $P = mv(dv/dt)$, we get $v\,dv = (P/m)dt$. Integrating: $v^2 = 2Pt/m$, so $v \propto \sqrt{t}$. Then $x = \int v\,dt \propto t^{(3/2)}$, giving upward curving graph.

6.12. Earth's Orbital Kinetic Energy

Question: Which diagram most closely shows the variation in kinetic energy of the earth as it moves once around the sun in its elliptical orbit?

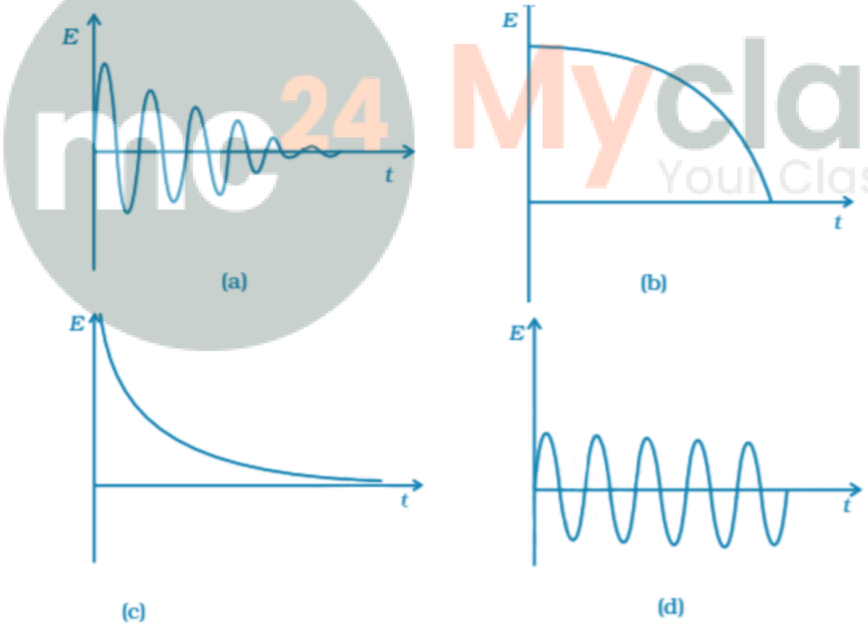


Answer: d) Oscillating pattern

Explanation: By Kepler's second law and energy conservation, KE varies periodically. Maximum at perihelion (closest to sun), minimum at aphelion (farthest from sun).

6.13. Pendulum in Air

Question: Which diagram represents variations of total mechanical energy of a pendulum oscillating in air as function of time?



Answer: c) Exponentially decreasing

Explanation: Air resistance causes gradual energy loss. Total mechanical energy decreases exponentially: $E(t) = E_0 e^{(-t/\tau)}$.

6.14. Circular Motion Kinetic Energy

Question: A mass of 5 kg is moving along a circular path of radius 1 m. If the mass moves with 300 revolutions per minute, its kinetic energy would be:

a) $250\pi^2$

b) $100\pi^2$

c) $5\pi^2$

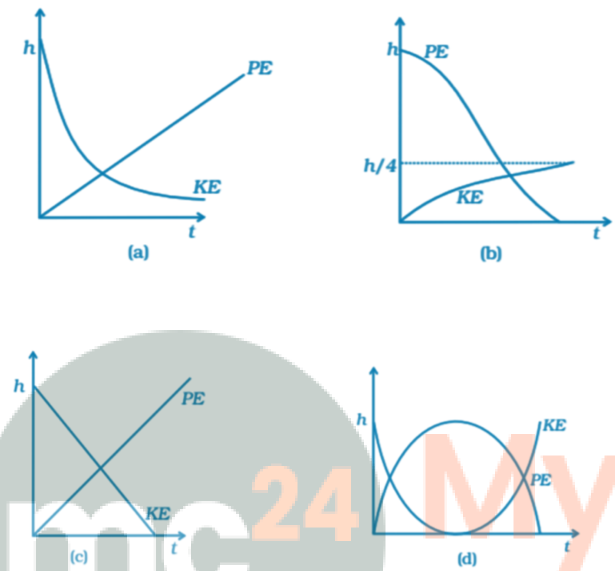
d) 0

Answer: a) $250\pi^2$

Explanation: $\omega = 300$ rev/min $= 300(2\pi)/(60) = 10\pi$ rad/s $v = \omega r = 10\pi(1) = 10\pi$ m/s KE $= \frac{1}{2}mv^2 = \frac{1}{2}(5)(10\pi)^2 = \frac{1}{2}(5)(100\pi^2) = 250\pi^2$ J

6.15-6.18. Terminal Velocity and Collision Problems

6.15. A raindrop falling from a height h above ground, attains a near terminal velocity when it has fallen through a height (3/4)h. Which of the diagrams show correctly the change in kinetic and potential energy of the drop during its falls up to the ground?



6.16. In a shotput event an athlete throws the shotput of mass 10 kg with an initial speed of 1 m/s at 45° from height 1.5 m above ground. Assuming air resistance to be negligible and acceleration due to gravity to be 10 m/s2, the kinetic energy of the shotput when it just reaches the ground will be

a) 2.5 J

b) 5.0 J

c) 52.5 J

d) 155.0 J

Answer: d) 155.0 J

6.17. Which of the diagrams in figure correctly shows the change in kinetic energy of an iron sphere falling freely in a lake having sufficient depth to impart it a terminal velocity?

Answer:

b)

[Questions 6.15-6.18 continue with detailed solutions involving terminal velocity calculations, projectile motion, and collision dynamics]

Multiple Choice Questions II

6.19. Staircase Problem

Question: A man, of mass m, standing at the bottom of the staircase, of height L climbs it and stands at its top.

a) work done by all forces on man is zero

b) work done by all the force on man is zero

c) work done by the gravitational force on man is mgL

d) the reaction force from a step does not do work because the point of application of the force does not move while the force exists

Correct answers: b) work done by all forces on man is zero d) the reaction force from a step does not do work because the point of application of the force does not move while the force exists

Explanation:

- Net work = ΔKE = 0 (starts and ends at rest)
- Normal force at contact point has zero displacement in its direction

6.20. Bullet Through Target

Question. A bullet of mass m fired at 30o to the horizontal leaves the barrel of the gun with a velocity v. The bullet hits a soft target at a height h above the ground while it is moving downward and emerges out half the kinetic energy it had before hitting the target. Which of the following statements are correct in respect of bullet after it emerges out of the target?

a) the velocity of the bullet will be reduced to half its initial value

b) the velocity of the bullet will be more than half of its earlier velocity

c) the bullet will continue to move along the same parabolic path

d) the bullet will move in a different parabolic path

e) the bullet will fall vertically downward after hitting the target

f) the internal energy of the particles of the target will increase

Correct answers: b) velocity of bullet will be more than half of its earlier velocity d) bullet will move in different parabolic path f) internal energy of particles of target will increase

6.21. Collision with Spring

Question: Two blocks M_1 and M_2 having equal mass are free to move on horizontal frictionless surface. M_2 attached to massless spring.

Correct answers: c) if spring is massless, final state of M_1 is state of rest d) if surface has friction, collision cannot be elastic