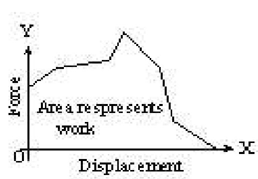
WORK, POWER & ENERGY

SYNOPSIS

WORK

- Work is done by a force when it acts on a body and displaces it such that the displacement has a component in the direction of the force.
- When a constant force 'F' acts on a body and produces in it a displacement 's' in a direction making an angle 'θ', then the work done W = F s cosθ. In vector notation, $W = \overline{F} \cdot \overline{s}$. Thus work is a scalar.
- When the angle θ between the force and displacement is 0°, then W = F s. The work done is maximum.
  When the angle θ between the force and displacement is 90°, then W = 0. The work done is zero
  When the angle θ between the force and displacement is 180°, then W = – F s. The work done is negative.
  When θ is acute, the work done by the force is positive and if θ is obtuse, the work done by the force is negative.
- •SI unit of work is *joule* (J), CGS unit of work is *erg*. $1\,joule = 10^7\,erg$. The dimensional formula of work is $[M L^2 T^{-2}]$.
  Other units of work are i) Calorie = 4.2 J
  • Electron volt (eV) = 1.6×10^{-19} J
  • Kilowatt hour (kWh) = 3.6×10^6 J.
- When a body moves in a circular path under the action of a centripetal force, such as an artificial satellite orbiting the Earth, the work done by the centripetal force is *zero* as the force is always perpendicular to the direction of motion.
- If a force linearly changes (*either increasing or decreasing*) from F_1 to F_2 over a displacement 's', the work done is calculated by the formula $W = \left(\frac{F_1 + F_2}{2}\right)s$.
- When force is varying irregularly, a graph is drawn between the displacement 's' on X-axis and the force 'F' on the Y-axis. Work done = area under F – s graph.



- Work done in compressing or expanding a spring: $W = ½ K x^2$ where 'K' is the force constant of the spring and 'x' is the extension or compression.
  Work done in changing the elongation of a spring from x_1 to x_2 is W = ½ K($x_2^2 - x_1^2$)
- Work done in lifting an object of finite dimensions: $W = m g h$, where 'm' is the mass of the object, 'g' is acceleration due to gravity and 'h' is the height through which the centre of mass of the body rises.
- Work done in pulling the bob of a simple pendulum of length 'l' through an angle 'θ' is given by $W = mgl(1 - \cos\theta)$, where 'm' is the mass of the bob, g is the acceleration due to gravity.
- Work done in giving or imparting a velocity 'v' to a body of mass 'm' is W = ½ mv^2.
- When the body moves on a rough horizontal surface, the force of friction is μmg. If 's' is the displacement, work done against friction $W = \mu\, mgs$. This work is converted into heat. The calories produced = μmgs/ J, where J = 4.2 joule/calorie.

POWER

- Time rate of doing work or spending energy is called power.
  $\text{Power} = \dfrac{\text{Work done or energy spent}}{\text{Time taken}}$. If 'W' work is done in a time interval 't', the average power P is calculated by $P = \dfrac{W}{t}$.
  Power is a scalar.
- SI unit of power is watt (W). CGS unit of power is erg s^{-1}. Dimensional formula of power $[M L^2 T^{-3}]$. Other units of power are kilo watt (kW) and horse power. One horse power (H.P.) = 746 W.
- Instantaneous power: If ΔW is the work done in a time Δt, the instantaneous power,
  $P = \underset{\Delta t \to 0}{Lt}\left(\dfrac{\Delta W}{\Delta t}\right) = \dfrac{dW}{dt}$. It is also calculated by $P = F\,v\cos\theta$ or $P = \overline{F} \cdot \overline{v}$
- The power of a machine gun firing 'n' bullets each of mass 'm' with a velocity 'v' in a time interval 't' is given by $P = \dfrac{mnv^2}{2t}$

- If a motor pump set lifts water of mass 'm' over a head or height of 'h' in a time of 't', its output power $P = \frac{mgh}{t}$. If 'η' is the efficiency of the motor pump set, the input power $P_i = \frac{mgh}{t\eta}$.
- 18. When sand falls at the rate of $\frac{dm}{dt}$ on to a conveyor belt moving with a uniform velocity 'v', the additional force required to keep the belt moving with the same velocity 'v' is given by $F = v\frac{dm}{dt}$. The additional power required is given by $P = v^2 \frac{dm}{dt}$.
- When a liquid of density 'd' is coming out of a hose pipe of area of cross section 'A' with a velocity 'v' and strikes normally a wall and stops dead, then the force exerted by the liquid on the wall is $F = d\,A\,v^2$, and the power exerted by the liquid is $P = d\,A\,v^3$.
- If a block of mass 'm' moves on a rough horizontal surface (coefficient of friction μ) with constant velocity 'v', the force required $F = \mu mg$ and the power required $P = \mu mgv$.

ENERGY

- Energy is ability or capacity to do work. Energy is something that can be converted to work. When a body or system possesses energy, it is capable of doing work.
- Energy is a scalar. Energy has the same units and dimensions as work. Kilo Watt Hour (kWh) is a special unit of energy. 1 kWh = 3.6×10^6 J.
- Energy has many forms, such as mechanical, thermal, chemical, electrical etc.,
- Potential energy: Energy possessed by a body or system by virtue of the relative positions of its parts or by virtue of its position in a *force field*. Ex. Water stored at a height, compressed spring.
- Gravitational potential energy of a body of mass 'm' at a height 'h' above the ground is given by $U = mgh$ [$\because$ h << R, the radius of Earth]. This is to be used only when 'h' is very small compared to the radius of earth (R).
For large heights comparable to radius of earth, $U = \frac{mgRh}{R+h}$. For infinite height, $U = mgR$.
- Potential energy of a compressed or elongated spring: If a spring of force constant 'K' is compressed or elongated over a distance 'x', the potential energy stored is $U = \frac{1}{2}Kx^2$.
- Gravitational potential energy of a two body system $U = -\frac{Gm_1m_2}{r}$.
- Energy possessed by a body by virtue of motion is called kinetic energy. It is measured through the amount of work the body can do before coming to rest. A body of mass 'm' moving with a velocity 'v' has kinetic energy $K = \frac{1}{2}mv^2$.
- Kinetic energy in terms of linear momentum 'p' is given by $K = \frac{1}{2}p\,v$ and $K = \frac{p^2}{2m}$
- When two bodies have the same kinetic energy, the lighter body has less momentum. On the other hand when two bodies have the same momentum, the lighter body will have more kinetic energy.
- A body cannot have kinetic energy without momentum and cannot have momentum without kinetic energy.
- Rest energy: Every body possesses a certain inherent amount of energy by virtue of its mass called rest energy even if it is not moving (so that KE = 0) and is not being acted on by a force (so that PE = 0). The rest energy is given by $E = mc^2$

WORK ENERGY THEOREMS

- Work-energy theorem: Work done by the resultant force on a body is equal to the change in its kinetic energy. $F\,s = W = ½\,mv^2 - ½\,mu^2$ or $W = K_f - K_i$.
- Work done by the resultant force acting on a body is equal to the change in its potential energy. $F\,s = W = U_f - U_i$.
- In a more general case the work done on a body by the resultant force is equal to increase in its total mechanical energy (which includes both kinetic and potential energies).
$F\,s = W = E_f - E_i$, where E_i and E_f are the initial and final total mechanical energies.

LAW OF CONSERVATION OF ENERGY

- Energy can neither be created nor destroyed. The total energy of a system remains constant. However, energy may be transformed from one form to another form in a system.

- In the case of a freely falling body, the potential energy starts decreasing and kinetic energy starts increasing. At any point on the path, the sum of potential and kinetic energies remains constant and equal to the initial potential energy.
- In the case of a body projected vertically upward from the ground, the kinetic energy starts decreasing and the potential energy starts increasing. At any point on the path, the sum of potential and kinetic energies remains constant and equal to initial kinetic energy.
- In the absence of non-conservative forces like friction, air resistance etc., the loss of potential energy will always be equal to the gain of kinetic energy or the loss of kinetic energy will always be equal to the gain of potential energy.
- In the case of a body thrown slantwise from the ground, the potential energy first increases and then decreases, while the kinetic energy first decreases and then increases. When the body is at the highest point of the path the potential energy $U = \frac{1}{2}mu^2 \sin^2\theta$ and kinetic energy $K = \frac{1}{2}mu^2\cos^2\theta$. The total mechanical energy at any point on the parabolic path is $\frac{1}{2}mu^2$.
- In the case of a simple pendulum, released from the position when the string is horizontal, its velocity when it makes an angle θ with the vertical is $v = \sqrt{2gl\cos\theta}$ and the velocity of the bob at the lowest position is $v = \sqrt{2gl}$.

CONCEPTUAL QUESTIONS

1. In which of the following, the work done by the mentioned force is negative? The work done by
1) the tension of the cable while the lift is ascending
2) the gravitational force when a body slides down an inclined place
3) the applied force in maintaining uniform motion of a block on a rough horizontal surface
4) the gravitational force when a body is thrown up

2. A man pushes a wall and fails to displace it. He does
1) negative work
2) positive but not maximum work
3) maximum work 4) no work at all

3. A bucket full of water is drawn up by a person. In this case the work done by the gravitational force is
1) negative because the force and displacement are in opposite directions
2) positive because the force and displacement are in the same direction
3) negative because the force and displacement are in the same direction
4) positive because the force and displacement are in opposite directions

4. A man is rowing a boat upstream and in spite of that the boat is found to be not moving with respect to the bank. The work done by the man is
1) zero 2) positive
3) negative 4) may be +ve or – ve

5. A ball is thrown vertically up wards from the ground. Regarding the work done by air resistance, which of the following is correct?
1) work done is positive during the ascent and negative during the descent
2) work done is positive during the ascent and positive during the descent
3) work done is negative during the ascent and positive during the descent
4) work done is negative during the ascent and negative during the descent

6. An agent is moving a positively charged body towards another fixed positive charge. The work done by the agent is
1) positive 2) negative
3) zero 4) may be positive or negative

7. If U represents potential energy of a system, then dU/dx represents
1) power 2) force 3) momentum 4) work

8. A shell explodes into two fragments of unequal masses, then the two fragments will have
1) unequal speeds and equal kinetic energies
2) equal speeds and unequal kinetic energies
3) unequal speeds and unequal kinetic energies
4) equal speeds and equal kinetic energies.

9. A curve is drawn expressing the kinetic energy of a particle as a function of the distance traversed (on X-axis). The slope of this curve represents the instantaneous
1) velocity 2) acceleration 3) force 4) power

10. When the momentum of a body is doubled, the kinetic energy is
1) doubled 2) halved
3) increases four times 4) increases three times

11. A shell is rolling on a horizontal surface. Suddenly it explodes. Neglecting the frictional forces its total
1) momentum increases, kinetic energy increases
2) momentum decreases, kinetic energy increases
3) momentum remains constant, kinetic energy increases
4) momentum remains constant, kinetic energy decreases

12. For the same kinetic energy, the momentum shall be maximum for which of the following particle?
1) electron 2) proton
3) deuteron 4) alpha particle

13. A cricket ball and a ping-pong ball are dropped from the same height in a vacuum chamber from same height. When they have fallen half way down, they have the same
1) velocity 2) potential energy
3) kinetic energy 4) rest energy

14. A cyclist free-wheels from the top of a hill, gathers speed going down the hill, applies his brakes and eventually comes to rest at the bottom of the hill. Which one of the following energy changes take place?
1) Potential to kinetic to heat energy
2) Kinetic to potential to heat energy
3) Chemical to heat to potential energy
4) Kinetic to heat to chemical energy

15. If the momentum of a particle is plotted on X-axis and its kinetic energy on the Y-axis, the graph is a
1) straight line 2) parabola
3) rectangular hyperbola 4) circle

16. If 'E' represents total mechanical energy of a system while 'U' represents the potential energy, then E–U is
1) always zero 2) always less than zero
3) always greater than zero
4) either positive or negative

17. When two identical balls are moving with equal speeds in opposite direction, which of the following is true? For the system of two bodies
1) momentum is zero, kinetic energy is zero
2) momentum is not zero, kinetic energy is zero
3) momentum is zero, kinetic energy not zero
4) momentum is not zero, kinetic energy is not zero

18. A particle is projected vertically upwards. Then, as it ascends, its
1) kinetic energy decreases uniformly with time
2) velocity decreases uniformly with height
3) potential energy increases uniformly with time
4) velocity decreases uniformly with time

19. For a body with potential energy 'U', kinetic energy 'T' and total mechanical energy 'E', the condition for motion (to attain a non-zero speed) is
1) E > U 2) E < U 3) E = U 4) E < T

20. For a body thrown vertically upwards, its direction of motion changes at the point where its total mechanical energy is
1) greater than the potential energy
2) less than the potential energy
3) equal to the potential energy
4) zero

21. The change in kinetic energy per unit 'space' (distance) is equal to
1) power 2) momentum
3) force 4) pressure

22. The product of linear momentum and velocity of a body represents
1) half of the kinetic energy of the body
2) kinetic energy of the body
3) twice of the kinetic energy of the body
4) mass of the body

23. The change in gravitational potential energy per unit 'space' (distance) of a body represents
1) mass 2) kinetic energy
3) linear momentum 4) weight

24. A particle starting from rest moves along a straight line with uniform acceleration. Its kinetic energy is 'K' when its displacement is 's'. A graph is drawn between 'K' (on Y-axis) and 's' (on X-axis). The shape of the graph is
1) straight line not passing through the origin
2) parabola
3) straight line passing through the origin
4) rectangular hyperbola

KEY

1) 4	2) 4	3) 1	4) 2	5) 4
6) 1	7) 2	8) 3	9) 3	10) 3
11) 3	12) 4	13) 1	14) 1	15) 2
16) 3	17) 3	18) 4	19) 1	20) 3
21) 3	22) 3	23) 4	24) 3	

LEVEL-I

1. A staircase has 40 steps each of width 35 cm and height 25 cm. A boy of mass 20 kg ascends the staircase. The work done by him is (take g = 10 m s^{-2})
1) 2×10^5 J 2) 4.8×10^3 J
3) 2×10^3 J 4) 4.8×10^5 J

2. A body of mass 5 kg is moved up over 10 m along the line of greatest slope of a smooth inclined plane of inclination of 30° with the horizontal. If $g = 10\,m/s^2$, the work done will be
1) 500 J 2) $250\sqrt{3}$ J 3) 250 J 4) $250/\sqrt{3}$ J

3. Work done by the gravitational force on a body of mass "m" moving on a smooth horizontal surface through a distance 's' is
1) mgs 2) –mgs 3) 0 4) 2 mgs

4. A body of mass 1 kg is made to travel with a uniform acceleration of 30 cm/s^2 over a distance of 2 m, the work done is
1) 6 J 2) 60 J 3) 0.6 J 4) 0.3 J

5. A weight lifter jerks 220 kg vertically through 1.5 meters and holds still at that height for two minutes. The works done by him in lifting and in holding it still are respectively
1) 220J, 330J 2) 3234 J, 0
3) 2334 J, 10 J 4) 0, 3234 J

6. A uniform cylinder of radius 'r' length 'L' and mass 'm' is lying on the ground with the curved surface touching the ground. If it is to be oriented on the ground with the flat circular end in contact with the ground the work to be done is
1) mg[(L/2)–r] 2) mL[(g/2)–r]
3) mr(gL –1) 4) mgLr

7. A bicycle chain of length 1.6 m and of mass 1 kg is lying on a horizontal floor. If $g = 10\,ms^{-2}$, the work done in lifting it with one end touching the floor and the other end 1.6 m above the floor is
1) 10 J 2) 3.2 J 3) 8 J 4) 16 J

8. A meter scale of mass 400 gm is lying horizontally on the floor. If it is to be held vertically with one end touching the floor, the work to be done is
1) 6 J 2) 4 J 3) 40 J 4) 2 J

9. A rain drop of mass (1/10) gram falls vertically at constant speed under the influence of the forces of gravity and viscous drag. In falling through 100 m, the work done by gravity is
1) 0.98 J 2) 0.098 J
3) 9.8 J 4) 98 J

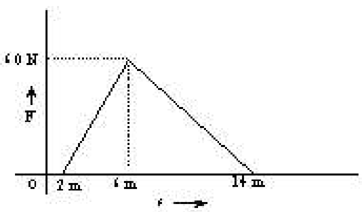
10. A force F is applied on a lawn mover at an angle of 60° with the horizontal. If it moves through a distance x, the work done by the force is
1) Fx/2 2) F/2x 3) 2Fx 4) 2x/F

11. A man weighing 80 kg climbs a staircase carrying a 20 kg load. The staircase has 40 steps each of 25 cm height. If he takes 20 seconds to climb, the work done is
1) 9800 J 2) 490 J
3) 98×10^5 J 4) 7840 J

12. A force $\overline{F} = 6i - 8j$ N, acts on a particle and displaces it over 4 m along the X-axis and then displaces it over 6 m along the Y-axis. The total work done during the two displacements is
1) 72 J 2) 24 J 3) – 24 J 4) zero

13. A lawn roller is pulled along a horizontal surface through a distance of 20 m by a rope with a force of 200 N. If the rope makes an angle of 60° with the vertical while pulling, the amount of work done by the pulling force is
1) 4000 J 2) 1000 J 3) $2000\sqrt{3}$ J 4) 2000 J

14. A force acts on a body and displaces it in its direction. The graph shows the relation between the force and displacement, the work done by the force is



1) 420 J 2) 360 J 3) 840 J 4) 720 J

15. A uniform chain is held on a frictionless table with half of its length hanging over the edge. If the chain has a mass 'm' and length 'L', how much work is required to pull the hanging part back onto the table?
1) mgL/4 2) mgL/2
3) mgL/8 4) mgL/16

16. A tennis ball has a mass of 56.7 gm and is served by a player with a speed of 180 kmph. The work done in serving the ball is nearly
1) 710 J 2) 71 J 3) 918 J 4) 91.8 J

17. A cyclotron accelerates a proton to a final speed of $3 \times 10^7\,m\,s^{-1}$, which is initially at rest. The work done on the proton in mega electron volts, by the electrical field of the cyclotron is (Mass of the proton is 1.6×10^{-27} kg)
1) 0.45 2) 4.5 3) 45 4) 450

18. A man carries a load of 50 kg through a height of 40 m in 25 seconds. If the power of the man is 1568 W, his mass is
1) 5 kg 2) 1000 kg 3) 200 kg 4) 50 kg

19. A boy whose weight is 600 N runs up a flight of stairs 10 m high in a time of 12 s. The average power he develops, in watts is
1) 72 2) 500 3) 720 4) 5000

20. An electric motor creates a tension of 4500 newton in a hoisting cable and reels it in at the rate of 2m/s. What is the power of the motor?
1) 15 kW 2) 9 kW 3) 225 W 4) 9000 kW

21. A motor drives a body along a straight line with a steady force. If the body starts from rest, the

power P developed by the motor must vary with time 't' according to
1) $P \propto 1/t$ 2) $P \propto t$ 3) $P \propto t^0$ 4) $P \propto t^2$

22. It is said that the power of human heart is typically 10 W for a 70 kg adult. In one year time the total energy required expressed in kWh will be approximately
1) 10 kWh 2) 100 kWh
3) 1000 kWh 4) 1 kWh

23. A juggler throws continuously balls at the rate of three in each second each with a velocity of 10 m s^{-1}. If the mass of each ball is 0.05 kg his power is
1) 2 W 2) 50 W 3) 0.5 W 4) 7.5 W

24. A pump delivers water at the rate of 2400 litres in six minutes over a head of 12 m. If g = 10 m/s^2, its power is
1) 200 W 2) 800 W 3) 240 W 4) 24 kW

25. A boy blowing a whistle sends in air at 2 gm/sec with a speed of 150 m/s. His lung power is
1) 2.25 W 2) 22.5 W 3) 225 W 4) 0.225 W

26. A pump lifts 500 litres of water from a well of depth 50 meter in 98 seconds. The power of the pump is
1) 9.8 kW 2) 10 kW 3) 5 kW 4) 2.5 kW

27. A motor pump set of efficiency 80 %, lifts 800 litres of water in 19.6 seconds over a head of 20 m. Its input power is
1) 64 kW 2) 40 kW 3) 10 kW 4) 196 kW

28. An electric motor in a crane while lifting a load produces a tension of 4000 N in the cable attached to the load. If the motor is winding the cable at the rate of 3 m s^{-1}, the power of the motor expressed in kilo watt units must be
1) 4 2) 3 3) 12 4) 6

29. A crane is powered by a motor delivering 20 kW. The crane is raising a load of 5 tonnes. If g = 10 m s^{-2}, the maximum speed with which the load can be lifted is
1) 40 m s^{-1} 2) 4 m s^{-1}
3) 0.04 m s^{-1} 4) 0.4 m s^{-1}

30. An electric motor operates with an efficiency of 90 %. A pump operated by the motor has an efficiency of 80 %. The overall efficiency of the system is
1) 85 % 2) 100 % 3) 72 % 4) 60 %

31. A car weighing 1000 kg is going up an incline with a slope of 2 in 25 at a steady speed of 18 kph. If g = 10 m s^{-2}, the power of its engine is
1) 4 kW 2) 50 kW 3) 625 kW 4) 25 kW

32. A machine gun fires 420 bullets per minute. The velocity of each of the bullet is 300 m s^{-1} and the mass of each bullet is 1 gm. The power of machine gun is
1) 315W 2) 315000W 3) 630W 4) 3150 W

33. A machine gun of mass "M" fires "n" bullets each of mass "m" with a velocity "v" in a time "t". The power of the machine gun is
1) $mMnv^2/2t$ 2) $mnv^2/2t$
3) $Mnv^2/2t$ 4) mnv/t

34. An engine lifts a load of 1200 N from a depth of 200 m in four minutes bringing it to the ground level. The power developed by the engine is
1) 500 W 2) 5,000 W
3) 10,000 W 4) 1000 W

35. A crane can lift up 10,000 kg of coal in 1 hour from a mine of 180 m depth. If the efficiency of the crane is 80 %, its input power must be (g = 10 m s^{-2})
1) 5 kW 2) 6.25 kW 3) 50 kW 4) 62.5 kW

36. A 1 kg mass at rest is subjected to an acceleration of 5 m/s^2 and travels 40 m. The average power during the motion is
1) 40 W 2)) 8 W 3) 50 W 4) 200 W

37. If the power of the motor of a water pump is 3 kW, then the volume of water that can be lifted to a height of 10m in one minute by the pump is (g = 10 m s^{-2})
1) 1800 liters 2) 180 liters
3) 18,000 liters 4) 18 liters

38. A machine gun fires 180 bullets per minute with a velocity of 300 m s^{-1}. If the mass of each bullet is 10 gm, the power of the machine gun will be
1) 1.35 kW 2) 0.675 kW
3) 5.4 kW 4) 2.7 kW

39. A particle moves with a velocity $(5\hat{i}-3\hat{j}+6\hat{k})$ m/s under the influence of a constant force $(10\hat{i}+10\hat{j}+20\hat{k})$ N. The instantaneous power applied to the particle is
1) 200 W 2) 40 W 3) 140 W 4) 170 W

40. The power of a crane is 6.25 kW. How much mass of coal it can lift in 1 hour from a mine of 100 m depth? The efficiency of the crane is 80%and g = 10 m s^{-2}.
1) 1800 kg 2) 18,000 kg
3) 180 kg 4) 1,80,000 kg

41. A machine gun fires 240 bullets per minute with a certain velocity. If the mass of each bullet is 10 gm and the power of the gun is 7.2 kW, the velocity with which each bullet is fired must be
1) 300 m/s 2) 600 m/s 3) 1200 m/s 4) 60 m/s

42. A spring when compressed by 4 cm has 2 J energy stored in it. The force required to extend it by 8 cm will be
1) 20 N 2) 2 N 3) 200 N 4) 2000 N

43. A tank of size 10 m × 10 m × 10 m is full of water and built on the ground. If g = 10 m s^{-2}, the potential energy of the water in the tank is
1) 5×10^7 J 2) 1×10^8 J
3) 5×10^4 J 4) 5×10^5 J

44. The elastic potential energy of a stretched spring is given by $E = 50x^2$ where x is the displacement in meter and E is in joule, then the force constant of the spring is
1) 50 Nm 2) 100 N m^{-1}
3) 100 N/m² 4) 100 Nm

45. An inelastic ball falls from a height of 100 meters. It loses 20 % of its total energy due to impact. The ball will now rise to a height of
1) 80 m 2) 120 m 3) 60 m 4) 9.8 m

46. A rubber ball falling from a height of 5 m rebounds from a hard floor to a height of 3.5 m. The % loss of energy during the impact is
1) 20% 2) 30% 3) 43% 4) 50%

47. The momentum of a particle is found to be numerically equal to its kinetic energy, if all units are expressed in SI, the velocity of the particle must be
1) 1 m/s 2) 2 m/s 3) ½ m/s 4) 4 m/s

48. If the momentum of a body is increased by 50 %, the percentage increase in its kinetic energy is
1) 100 2) 50 3) 125 4) 200

49. A body has a unit mass and is at a state of rest. Then suddenly it receives an impulse 'x', then it will acquire a kinetic energy of
1) x 2) x^2 3) $x^2/2$ 4) $2/x^2$

50. Two masses of 1 gm and 4 gm are moving with equal kinetic energies. The ratio of the magnitudes of their linear momenta is
1) 4 : 1 2) √2 : 1 3) 1 : 2 4) 2 : 1

51. Two bodies having kinetic energies K_1 and K_2 have equal masses. Their momenta are p_1 and p_2 respectively, then p_1/p_2 is
1) $K_1 : K_2$ 2) $K_2 : K_1$
3) $\sqrt{K_2} : \sqrt{K_1}$ 4) $\sqrt{K_1} : \sqrt{K_2}$

52. A neutron, one of the constituents of a nucleus, is found to pass two points 60 meters apart in a time interval of 1.8×10^{-4} sec. The mass of a neutron is 1.7×10^{-27} kg, assuming that the speed is constant, its kinetic energy is
1) 9.3×10^{-17} joule 2) 9.3×10^{-14} joule
3) 9.3×10^{-21} joule 4) 9.3×10^{-11} joule

53. A 150 gm mass has a velocity (2i + 6j) m/s at a certain instant. It's kinetic energy is
1) 6 J 2) 2 J 3) 3 J 4) 8 J

54. A body starts from rest and moves with uniform acceleration. What is the ratio of kinetic energies at the end of 1st, 2nd and 3rd seconds of its journey?
1) 1 : 8 : 27 2) 1 : 2 : 3
3) 1 : 4 : 9 4) 3 : 2 : 1

55. A shot is fired at 30° with the vertical from a point on the ground with kinetic energy K. If air resistance is ignored, the kinetic energy at the top of the trajectory is
1) 3K/4 2) K/2 3) K 4) K/4

56. On increasing the speed of a body to 2 m s^{-1}, its kinetic energy is quadrupled. Then its original speed must be
1) 0.25 m s^{-1} 2) 1 m s^{-1}
3) 4 m s^{-1} 4) 2 m s^{-1}

57. A liquid of specific gravity 0.8 is flowing in a pipe line with a speed of 2 m/s. The K.E. per cubic meter of it is
1) 160 J 2) 1600 J
3) 160.5 J 4) 1.6 J

58. A body starts from rest and is acted on by a constant force. The ratio of kinetic energy gained by it in the first five seconds to that gained in the next five second is
1) 2 : 1 2) 1 : 1 3) 3 : 1 4) 1 : 3

59. If the mass of a body is halved and its speed doubled, then its kinetic energy increased by
1) 250 % 2) 200 % 3) 50 % 4) 100 %

60. A proton and a deuteron have kinetic energies in the ratio 1 : 2. The ratio of their linear momenta is
1) 1 : √2 2) √2 : 1 3) 2 : 1 4) 1 : 2

61. The kinetic energy in joules of a freely falling body as a function of time is given by the equation : $K = 25\,t^2$. If the acceleration due to gravity is 10 m s^{-2}, the weight of the body must be
1) 10 N 2) 20 N 3) 5 N 4) 25 N

62. A stationary U^{238} nucleus emits an α - particle and is converted into Th^{234} nucleus. If the kinetic energy of the α - particles is 1.67 MeV, the kinetic energy of the recoiling Th^{234} nucleus is
1) 0.028 MeV 2) 0.01 MeV
3) 0.04 MeV 4) 0.08 MeV

63. A bullet of mass 10 gm strikes a target at 400 m/s velocity and loses half of its initial velocity. The loss of kinetic energy in joules is
1) 800 2) 200 3) 400 4) 600

64. A 60 kg boy lying on a surface of negligible friction throws horizontally a stone of mass 1 kg with a speed of 12 m/s away from him. As a result with what kinetic energy he moves back?
1) 2.4 J 2) 72 J 3) 1.2 J 4) 36 J

65. A body of mass 4 kg is moving with a momentum of 12 kg ms^{-1}. Its kinetic energy is
1) 48 J 2) 24 J 3) 96 J 4) 12 J

66. An object is acted on by a retarding force of 10 N and at a particular instant its kinetic energy is 6 J. The object will come to rest after it has traveled a distance of
1) 3/5 m 2) 5/3 m 3) 4 m 4) 16 m

67. By applying the brakes without causing a skid, the driver of a car is able to stop his car in a distance of 5 m, if it is going at 36 kph. If the car were going at 72 kph, using the same brakes, he can stop the car over a distance of
1) 10 m 2) 2.5 m 3) 20 m 4) 40 m

68. A block of mass 4 kg slides on a horizontal frictionless surface with a speed of 2 m/s. It is brought to rest in compressing a spring in its path. If the force constant of the spring is 400 N/m, by how much the spring will be compressed?
1) 2×10^{-2} m 2) 0.2 m
3) 20 m 4) 200 m

69. A bullet fired into a trunk of a tree loses 1/4 of its kinetic energy in traveling a distance of 5 cm. Before stopping it travels a further distance of
1) 150 cm 2) 1.5 cm 3) 1.25 cm 4) 15 cm

70. A ship of mass 3×10^7 kg initially at rest is pulled by a force of 5×10^4 N through a distance of 3 meters. Assuming that the resistance due to water is negligible, the speed of the ship is
1) 0.1 m/s 2) 1.5 m/s 3) 5 m/s 4) 60 m/s

71. A vehicle of mass 1000 kg is moving with a velocity of 15 m s^{-1}. It is brought to rest by applying brakes and locking the wheels. If the sliding friction between the tires and the rod is 6000 N, distance moved by the vehicle before coming to rest is
1) 37.5 m 2) 17.75 m 3) 75 m 4) 15 m

72. A body of mass 2 kg is projected with an initial velocity of 5 m s^{-1} along a rough horizontal table. The work done on the body by the frictional forces before it is brought to rest is
1) 250 J 2) 2.5 J 3) 10 J 4) 25 J

73. The mass of a simple pendulum bob is 100 gm. The length of the pendulum is 1 m. The bob is drawn aside from the equilibrium position so that the string makes an angle of 60° with the vertical and let go. The kinetic energy of the bob while crossing its equilibrium position will be
1) 0.49 J 2) 0.94 J 3) 1 J 4) 1.2 J

74. A 4.0 kg mass moving with a speed of 2.0 m/sec collides with a spring bumper of negligible mass and having a force constant 100 N/meter. The maximum compression of the spring bumper will be
1) 1.6 m 2) 0.4 m 3) 2.0 m 4) 1.0 m

75. A woman weighing 63 kg eats plum cake whose energy content is 9800 calories. If all this energy could be utilized by her, she can ascend a height of
1) 1 m 2) 67 m 3) 100 m 4) 42 m

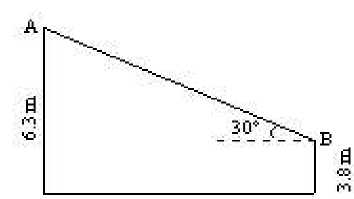
76. A stone of mass "m" initially at rest and dropped from a height "h" strikes the surface of the earth with a velocity "v". If the gravitational force acting on the stone is W, then which of the following identities is correct?
1) $mv - mh = 0$ 2) $\frac{1}{2} mv^2 - Wh^2 = 0$
3) $\frac{1}{2} mv^2 - Wh = 0$ 4) $\frac{1}{2} mv^2 - mh = 0$

77. A cradle is 'h' meters above the ground at the lowest position and 'H' meters when it is at the highest point. If 'v' is the maximum speed of the swing of total mass 'm' the relation between 'h' and 'H' is
1) $\frac{1}{2} mv^2 + h = H$ 2) $(v^2/2g) + h = H$
3) $(v^2/g) + 2h = H$ 4) $(v^2/2g) + H = h$

78. Two stones of masses m and 2 m are projected vertically upwards so as to reach the same height. The ratio of the kinetic energies of their projection is
1) 2 : 1 2) 1 : 2 3) 4 : 1 4) 1 : 4

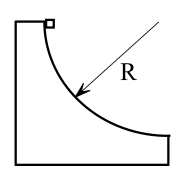
79. At what height above the ground must a mass of 5 kg be to have its P.E. equal in value to the K.E. possessed by it when it moves with a velocity of 10 m/s? (Assume g = 10 m/s^2)
1) 1 m 2) 5 m 3) 10 m 4) 50 m

80. AB is a frictionless inclined surface making an angle of 30 ° ð with horizontal. A is 6.3 m above the ground while B is 3.8 m above the ground. A block slides down from A, initially starting from rest. Its velocity on reaching B is



1) 7 m s^{-1} 2)14 m s^{-1} 3)7.4 m s^{-1}4) 4.9 m s^{-1}

81. A body slides down a fixed curved track that is one quadrant of a circle of radius R, as in the figure. If there is no friction and the body starts from rest, its speed at the bottom of the track is



1) 5gR 2) $\sqrt{5gR}$ 3) $\sqrt{2gR}$ 4) $\sqrt{gR}$

82. Assume that a polevaulter obtains all his height by the complete conversion of his KE into PE. If his speed just before placing his pole down is v, the height reached is given by

1) v/2g 2) $\sqrt{2vg}$ 3) $v^2/2g$ 4) $2g/v^2$

83. The bob of a pendulum is drawn aside so that it is at a height of 4.5 m above the ground and released. If it reaches the equilibrium position which is at a height of 2 m above the ground, the speed of the bob will be

1) 49 m/s 2) 7 m/s 3) $7\sqrt{2}$ m/s 4) $7/\sqrt{2}$ m/s

84. A man standing on the edge of the roof of a 20 m tall building projects a ball of mass 100 gm vertically up with a speed of 10 m s^{-1}. The kinetic energy of the ball when it reaches the ground will be [g = 10 m s^{-2}]

1) 5 J 2) 20 J 3) 25 J 4) zero

KEY

1) 3	2) 3	3) 3	4) 4	5) 2
6) 1	7) 3	8) 4	9) 2	10 1
11) 1	12) 3	13) 3	14) 2	15) 3
16) 2	17) 2	18) 4	19) 2	20) 2
21) 2	22) 2	23) 4	24) 2	25) 2
26) 4	27) 3	28) 3	29) 4	30) 3
31) 1	32) 1	33) 2	34) 4	35) 2
36) 3	37) 1	38) 1	39) 3	40) 2
41) 2	42) 3	43) 1	44) 2	45) 1
46) 2	47) 2	48) 3	49) 3	50) 3
51) 4	52) 1	53) 3	54) 3	55) 4
56) 2	57) 2	58) 4	59) 4	60) 4
61) 3	62) 1	63) 4	64) 3	65) 2
66) 1	67) 3	68) 2	69) 4	70) 1
71) 2	72) 4	73) 1	74) 2	75) 2
76) 3	77) 2	78) 2	79) 2	80) 1
81) 3	82) 3	83) 2	84) 3	

LEVEL – II

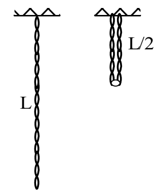
1. A chain of mass m and length 'L' is over hanging from the edge of a smooth horizontal table such that 3/4 th of its length is lying on the table. The work done in pulling the chain completely on to the table is

1) mgL/16 2) mgL/32
3) 3mgL/32 4) mgL/8

2. A 5.0 kg box rests on a horizontal surface. The coefficient of kinetic friction between the box and the surface is $\mu = 0.5$. A horizontal force pulls the box at constant velocity for 10 cm. The work done by the applied horizontal force nd the frictional force are respectively (take g=10m/s^2)

1) 2.5 J and 2.5 J 2) zero and 2.5 J
3) 2.5 J and zero 4) 2.5 J and – 2.5 J

3. A uniform chain of length 'L' and mass 'm' is hanging down vertically from a hook fixed to the roof. The work done in hooking the other end of the chain as shown is

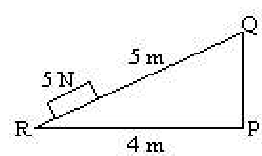


1) mgL 2) mgL/2 3) mgL/4 4) mgL/8

4. A solid rectangular block of mass 200 kg has the dimensions L = 2 m, b = 1 m, h = 0.5 m. It lies on a horizontal floor on sides L and b. The minimum work needed to turn it so that it lies on the sides b and h is

1) zero 2) 1500 J 3) 3000 J 4) 2000 J

5. A weight of 5 N is moved up a frictionless inclined plane from R to Q as shown. What is the work done in joules?



1) 15 2) 20 3) 25 4) 35

6. A particle moves under the effect of a force F = C x from x = 0 to x = x_1. The work done in the process is (treat C as a constant)

1) C^2 / x_1^2 2) Cx_1^2 3) ½ Cx_1^2 4) ½ C^2/x_1^2

7. Under the action of a force a 2 kg body moves such that its position 'x' in meters as a function of time 't' in seconds given by: $x = t^2/2$. The work done by the force in the first 5 seconds is

1) 2.5 J 2) 0.25 J 3) 25 J 4) 250 J

8. Two forces each of magnitude 10 N act simultaneously on a body with their directions inclined to each other at an angle of 120° and displaces the body over 10 m along the bisector of the angle between the two forces. Then the work done by each force is

1) 5 J 2) 1 J 3) 50 J 4) 100 J

9. 'n' identical cubes each of mass 'm' and edge 'L' are on a floor. If the cubes are to be arranged one over the other in a vertical stack, the work to be done is

1) Lmng (n–1)/2 2) Lg(n–1)/mn
3) (n–1)/Lmng 4) Lmng/2(n–1)

10. A spring obeying the linear law F = – Kx is first compressed by 10 cm and the work done is W_1. Next it is compressed by another 10 cm, the work done now is W_2, then $W_1 : W_2$

1) 1 : 3 2) 3 : 1 3) 1 : 6 4) 6 : 1

11. When a body of mass m slides down from the top of a smooth inclined plane of length L and inclination θ, the work done by the gravitational force on the body is
1) $mgL\cos\theta$ 2) $mgL\sin\theta$
3) $mgL\tan\theta$ 4) $2mgL\sin\theta$

12. A body of mass 'm' starting from rest is acted on by a force producing a velocity $v=\sqrt{k\times s}$ where k is a constant and s is displacement. The work done by the force in the first 't' seconds is
1) $m^2 k^2 t^2/8$ 2) $mk^2t^2/4$
3) $m k^2 t^2/8$ 4) $m^2 k^2 t/8$

13. A body of mass 5 kg at rest is under the action of a force which gives it a velocity given by $v = 3\times t$ m/s, here 't' is time in seconds. The work done by the force in two seconds will be
1) 90 J 2) 45 J 3) 180 J 4) 30 J

14. A body of mass 6 kg is subjected to a steady force, which causes some displacement in it. The equation of motion is given by: s (in meters) = 2 t^2, here 't' is time in seconds. The work done by the force in the first two seconds is
1) 192 J 2) 384 J 3) 96 J 4) 48 J

15. A tomato is thrown vertically upward from a point on the ground. As it rises to the highest point, the gravitational force does work of W_1 on it. As the tomato descends to the ground, the gravitational force does a work of W_2 on it. Regarding W_1 and W_2, which of the following is correct?
1) $W_1 = W_2$
2) W_1 is positive, W_2 is negative
3) W_1 is negative, W_2 is positive
4) both W_1 and W_2 are negative

16. A bucket of mass 'm' tied to a light rope is lowered at a constant acceleration of 'g/4'. If the bucket is lowered by a distance 'd', the work done by the rope will be (neglect the mass of the rope)
1) $\frac{1}{4}mgd$ 2) $\frac{3}{4}mgd$ 3) $-\frac{3}{4}mgd$ 4) $-\frac{5}{4}mgd$

17. A force $\bar{F} = 2\hat{i} + 3\hat{j} - 4\hat{k}\,N$ acts on a particle which is constrained to move in the XOY plane along the line x = y. If the particle moves $5\sqrt{2}\ m$, the work done by the force in joules is
1) $25\sqrt{2}$ 2) $5\sqrt{58}$ 3) 25 4) 10

18. Two rifles fire the same number of bullets in a given interval of time. The second fires bullets of mass twice that fired by the first and with a velocity that is half that of the first. The ratio of their powers is
1) 1 : 4 2) 4 : 1 3) 1 : 2 4) 2 : 1

19. A tank on the roof of a 20 m high building can hold 10 m^3 of water. The tank is to be filled from a pond on the ground in 20 minutes. If the pump has an efficiency of 60 %, the input power required is
1) 1.1 kW 2) 2.74 kW
3) 5.48 kW 4) 7.0 kW

20. From a waterfall, water is pouring down at the rate of 160 kg per second on the blades of a turbine. If the height of the fall be 50 m, the power delivered to the turbine is approximately equal to
1) 7.84×10^4 W 2) 7.84×10^7 W
3) 8400 W 4) 784 kW

21. A motor pump-set of efficiency 80 % lifts 6000 litres of water per minute from a well 20 meters deep. If $g = 10\ m\,s^{-2}$, its input power is
1) 20 kW 2) 25 kW 3) 16 kW 4) 250 kW

22. An electric fan, with effective area of cross-section 'A', accelerates air of density 'd' to a speed 'v'. What is the power needed for this process?
1) d Av 2) ½ d Av 3) d Av^2 4) ½ d Av^3

23. 50 kg of sand is deposited each second on to a conveyor belt moving at 5 $m\,s^{-1}$. The extra power required to maintain the belt in motion is
1) 1250 W 2) 250 W 3) 625 W 4) 2500 W

24. A machine lifts a load of 2 tonnes wt with an effort of 100 kg wt. when the effort moves through 5 m the load moves through 0.2 m. The efficiency of the machine is
1) 20 % 2) 40 % 3) 80% 4) 0.8 %

25. The input power to an electric motor is 200 kW. Its efficiency is 80 %. It operates a crane of efficiency 90 %. If the crane is lifting a load of 3.6 tonnes, the velocity with which the load moves is
1) 8 $m\,s^{-1}$ 2) 4 $m\,s^{-1}$ 3) 2 $m\,s^{-1}$ 4) 40 $m\,s^{-1}$

26. An engine lifts 2,250 litres of water per minute from a well 20 m deep. If 25 % energy of the engine is wasted, the power to be given to the engine must be
1) 29,400 W 2) 9,800 W
3) 7,350 W 4) 13,067 W

27. A body initially at rest has an acceleration of – 10 j m/s^2. If the force acting on the body is $\bar{F}$ = (2 i – 3 j + 5 k) N, the instantaneous power at t = 5 seconds will be
1) 100 W 2) 150 W 3) 50 W 4) 200 W

28. An electric pump takes 30 minutes to fill a tank of volume 30 m^3 with water. If the height over which the water is lifted be 30 m, and the efficiency of the pump is 50 %, the input electric power required by the pump is
1) 100,000 W 2) 10,000 W
3) 1000 W 4) 100 W

29. The human heart discharges 75 cm^3 of blood per beat against an average pressure of 10 cm of Hg. Assuming that the pulse frequency is 75 per minute, the power of the heart is (density of Hg = 13.6 gm cm^{-3})
1) 1.25 W 2) 12.5 W 3) 0.125 W 4) 125 W

30. An electric motor of power 300 W is used to drive the stirrer in a water bath. The work done in one minute, if 60 % of the energy of the motor is utilized to drive the stirrer will be
1)10,800J 2) 1080J 3)1,08,000J 4)108 J

31. An engine pumps a liquid of density 'd' continuously through a pipe of area of cross-section 'A'. If the speed of the liquid through the pipe is 'v', then the power of the engine is
1) $Adv^3/2$ 2) ½ Adv 3) $Adv^2/2$ 4) Adv^2

32. An electric pump draws water from a well of pth d = 50 m at a rate of 2 m^3 per second. The water is ejected from the pump with velocity v = 10 m s^{-1}. If the efficiency of the pump η = 80%, the input power consumption of the pump is (g = 10 m s^{-2})
1) 1100 kW 2) 880 kW
3) 1375 kW 4) 1080 kW

33. If g is the acceleration due to gravity on the earth's surface, the gain in potential energy of an object of mass M raised from a height R to a height of 2R above the surface of earth, where R is equal to the radius of the earth will be
1) MgR/2 2) 2 MgR/3 3) MgR/6 4) MgR/3

34. A rocket is fired up from the surface of the earth. What will be the increase in its potential energy at a height 'h'? The radius of the earth is 'R' and the acceleration due to gravity on the earth is 'g' and the mass of the rocket is 'M'
1) Mgh 2) Mg(Rh)
3) Mg(R + h) 4) Mgh/(1+h/R)

35. When a body of mass 'm' is moved from the surface of the earth to a height 'h', the change in gravitational potential energy is (M = mass of the earth. R = radius of earth)
1) $\frac{GMmh}{R(R+h)}$ 2) $\frac{GMmh}{R(R-h)}$
3) $\frac{GMmR}{R+h}$ 4) $\frac{GMmR}{R-h}$

36. A body freely falls from a certain height on to the ground in a time 't'. During the first one third of the interval it gains a kinetic energy ΔK_1 and during the last one third of the interval, it gains a kinetic energy ΔK_2. The ratio $\Delta K_1 : \Delta K_2$ is
1) 1 : 1 2) 1 : 3 3) 1 : 4 4) 1 : 5

37. Two identical bodies A and B each of mass 'm' are moving in the same direction with velocities of v_1 and v_2 respectively. The kinetic energy of B in the frame of reference attached to A is
1) $\frac{1}{2}mv_1^2$ 2) $\frac{1}{2}mv_2^2$
3) $\frac{1}{2}m(v_1-v_2)^2$ 4) $\frac{1}{2}m(v_1+v_2)^2$

38. A ball of mass 'm' at rest receives an impulse I_1 in the direction of north. After some time it received another impulse I_2 in the direction of south. The final kinetic energy of the ball is
1) $\frac{(I_1+I_2)^2}{2m}$ 2) $\frac{(I_1-I_2)^2}{2m}$
3) $\frac{I_1^2+I_2^2}{2m}$ 4) $\frac{I_1^2-I_2^2}{2m}$

39. The kinetic energy of a projectile at the highest point of its path is found to be 3/4th of its initial kinetic energy. If the body is projected from the ground, the angle of projection must be
1) 0° 2) 30° 3) 60° 4) 40°

40. A body of mass 2 kg falls from a height of 20 m at a place where acceleration due to gravity is 10 m s^{-2}, and is found to acquire a velocity of 15 m s^{-1}. The work done against the air esistance is
1) 400 J 2) 225 J 3) 175 J 4) zero

41. A simple pendulum bob has a mass "m" and length "L". The bob is drawn aside such that the string is horizontal and then it is released. The velocity of the bob while it crosses the equilibrium position is
1) $\sqrt{gL}$ 2) $\sqrt{2gL}$ 3) $\sqrt{5gL}$ 4) $\sqrt{3gL}$

42. The speed of a car changes from 0 to 5 m s^{-1} in the first phase and from 5 m s^{-1} to 10 m s^{-1} in the second phase and from 10 m s^{-1} to 15 m s^{-1} during the third phase. In which phase the increase in kinetic energy is more?
1) first phase 2) second phase
3) third phase 4) same in all the three phases

43. A block of mass 5 kg is initially at rest on a rough horizontal surface. A force of 45 N acts on it in a horizontal direction and pushes it over a distance of 2 m. The force of friction acting on the block is 25 N. The final kinetic energy of the block is
1) 40 J 2) 90 J 3) 50J 4) 140 J

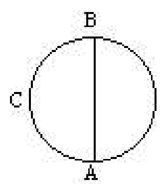
44. A 100 gm light bulb dropped from a tower reaches a velocity of 20 m/s after falling through 100 m. The energy transferred to the air due to viscous force is
1) 98 J 2) 20 J 3) 118 J 4) 78 J

45. A body is projected vertically upward from the ground with a velocity 'v' and is found to reach a height of R/2 where R is the radius of the earth. If 'g' is the acceleration due to gravity on the surface of the earth then 'v' is equal to
1) $\sqrt{2gR/3}$ 2) $\sqrt{gR}$
3) $\sqrt{3gR/2}$ 4) $\sqrt{gR/3}$

46. A trolley of mass 60 kg moves on a smooth horizontal surface and has kinetic energy 120 J. A mass of 40 kg is lowered vertically on to the trolley. The total kinetic energy of the system after lowering the mass is
1) 60 J 2) 72 J 3) 120 J 4) 144 J

47. A body is projected vertically upward with a kinetic energy of ½ mgR where 'm' is the mass of the body and 'R' is the radius of the earth and 'g' is the acceleration due to gravity near the surface of earth. The maximum height it can reach is
1) R/2 2) 3R/4 3) R 4) 3R/2

48. A circular track of radius 'R' is in a vertical plane. AB is a vertical diameter. The work done in moving a mass of 'm' along the path ACB is (g = acceleration due to gravity)



1) πR mg 2) 2 mgR 3) zero 4) $\pi R^2 mg$

49. A 2 kg block is dropped from a height of 0.4 m on to the top of a vertical helical spring whose force constant K is 1960 N m^{-1}. The spring then suffers a maximum compression of
1) 0.1 m 2) 0.01 m 3) 1 m 4) 1×10^{-3}

50. A body of mass 2 kg has a potential energy of 800 J when it is at a certain height. (g = 10 m/s^2). If it begins to fall, its velocity when its K.E. and P.E. are equal is
1) 4 m s^{-1} 2) 400 ms^{-1} 3)20 m s^{-1} 4)80 m s^{-1}

51. An object first falls from a height R and then the same object falls from a height 3R where R is radius of the earth. The ratio of the velocities with which it hits the ground will be
1) √2 : √3 2) √3 : √2 3) 1 : 1 4) √2 : 1

52. A bullet of mass 'm' is fired with a velocity 'v' into a fixed log of wood and penetrates a distance 's' before coming to rest. Assuming that the path of the bullet in the log of wood is horizontal, the average resistance offered by the log of wood is
1) $mv/2s^2$ 2) $mv^2/2s$ 3) $2s/mv^2$ 4) $ms^2/2v$

53. A body released at infinite distance from the earth starts falling towards it. If R is the radius of the earth, and g the acceleration due to gravity on the surface of the earth, then the velocity acquired by it before reaching the surface is
1) $\sqrt{2gR}$ 2) $\sqrt{gR}$ 3) $\sqrt{5gR}$ 4) gR

54. A toy gun consists of a spring and a rubber dart of mass 25 gm. When the spring is compressed by 4 cm and the dart is fired vertically, it projects the dart to a height of 2 m. If the spring is compressed by 8 cm and the same dart is projected vertically, the dart will rise to a height of
1) 16 m 2) 8 m 3) 4 m 4) 2 m

55. A body of mass 2 kg is at rest. A force of 4i + 3j – 5k N acts on it and displaces through 2i + j + 2k m. The velocity acquired by the body is
1) 0 2) 1 m s^{-1} 3) 2 m s^{-1} 4) ½ m s^{-1}

56. An elastic spring is compressed between two blocks of masses 1 kg and 2 kg resting on a smooth horizontal table as shown. If the spring has 12 J of energy and suddenly released, the velocity with which the larger block of 2 kg moves will be

1) 2 m/s 2) 4 m/s 3) 1 m/s 4) 8 m/s

57. A spring is held between two blocks of masses "m_1" and "m_2" but not connected to them and then the blocks are moved towards each other so as to compress the spring. If the blocks are suddenly released, and if K_1 and K_2 are the kinetic energies of the blocks when the spring just gets detached from the blocks, then the ratio $K_1 : K_2$ must be
1) $m_1 : m_2$ 2) $m_2 : m_1$
3) $m_1^2 : m_2^2$ 4) $m_2^2 : m_1^2$

58. A body of mass 10 kg projected vertically upward from the ground has potential energy 580 joules and kinetic energy 1380 joules at a certain point in its path. The velocity of projection of the body must be
1) 16.6 m s^{-1} 2) 19.8 m s^{-1}
3) 14 m s^{-1} 4) 10.8 m s^{-1}

59. Two trucks A and B are moving with the same kinetic energy. A is twice as massive as B. The same brake force is applied on A and B and they stop over distances "a" and "b". The correct relation between "a" and "b" is
1) a = 2 b 2) b = 2 a 3) a = b 4) a = 4 b

60. A man has twice the mass of a boy and has half the kinetic energy of the boy. The ratio of the speeds of the man and the boy must be
1) 2 : 1 2) 4 : 1 3) 1 : 4 4) 1 : 2

61. A block of mass 2 kg is on a smooth horizontal surface. A light spring of force constant 800 N/m has one end rigidly attached to a vertical wall and lying on that horizontal surface. Now the block is moved towards the wall compressing the spring over a distance of 5 cm and then suddenly released. By the time the spring regains its natural length and breaks contact with the block, the velocity acquired by the block will be

1) 200 m/s 2) 100 m/s 3) 2 m/s 4) 1 m/s

62. The velocity of a train is increased from 10 m s^{-1} to 25 m s^{-1} in 2 minutes due to the application of some force by its engine developing an average power of 525 kW. Neglecting frictional forces, the mass of the train must be

1) 2.4×10^4 kg 2) 2.4×10^5 kg
3) 2.4×10^6 kg 4) 2.4×10^3 kg

63. A rocket is projected vertically up with a velocity of 7.8 k m s^{-1} from the Earth's surface. Assuming that the resistance of the Earth's atmosphere is negligible, the height reached by it above the Earth's surface is nearly (Radius of the earth = 6400 km; g = 9.8 m s^{-2})

1) 3200 km 2) 6400 km
3) 12800 km 4) infinity

64. A typical rain drop formed in a cloud at an altitude of 800 m reaches the earth's surface with a speed of 8 m/s. The ratio of the me
chanical energy of the rain drop before and after the trip is

1) 500 : 1 2) 250 : 1 3) 125 : 1 4) 1000 : 1

65. A helicopter starts from the ground and reaches a height of 500 m, meanwhile attaining a velocity of 50 m/s. The energy spent by its engine for taking it to the height is E_1 and the energy spent by its engine to impart the velocity is E_2, then the ratio $E_1 : E_2$ is

1) 2 : 1 2) 4 : 1 3) 1 : 1 4) 1 : 4

66. The work done is raising a body from the ground to a height 'h' is found to be W_1. The work done to raise the same body from the ground to a height '3h' is found to be W_2. If $W_2 = 2 \times W_1$, the value of 'h' in terms of the radius 'R' of the earth is

1) 2R 2) R 3) R/2 4) R/3

67. A car is going with a linear momentum 'p'. When brakes are applied, it comes to a stop in a distance 's'. If the same car were going with a linear momentum '2p' and the brakes are applied, it comes to a stop in a distance of (assume that the brake force is same in the two cases)

1) 2s 2) s 3)4s 4) s/4

68. Two identical bodies each of mass 'm' are moving with velocities 'v_1' and 'v_2' respectively in the same direction. The kinetic energy of the system in the frame of reference attached to the center of mass is (v is relative velocity between the two bodies)

1) ¼ mv^2 2) ½ mv^2 3) mv^2 4) (1/8) mv^2

69. A bomb of mass 'm' initially at rest, on the ground suddenly explodes in to two fragments. The fragment of mass '2m/3' moves out with a velocity 'v'. With the total energy released during the explosion, the unexploded bomb can be raised to what height above the ground?

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

70. A ball is projected vertically up from a point on the ground with a certain initial velocity. At a certain point in its path, the ratio of the kinetic and potential energies is found to be 1 : 1. If the same ball were projected vertically up from the ground from the same point with twice the previous velocity, the ratio of the kinetic and potential energies at the same point will be

1) 1 : 1 2) 3 : 1 3) 7 : 1 4) 5 : 1

71. A bullet loses 1/10 of its velocity after penetrating a plank. How many planks in a row are required, to stop the bullet?

1) 6 2) 5 3) 11 4) 10

72. A 3-kg model rocket is launched straight up with sufficient initial speed to reach a maximum height of 100 m, even though air resistance (a non-conservative force) performs – 900 J of work on the rocket. The height the rocket would have gone without air resistance will be

1) 70 m 2) 130 m 3) 180 m 4) 230 m

KEY

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

LEVEL - III

1. The work done in lifting a stone of mass 10 kg and specific gravity 3 from the bed of a lake to a height of 6 m inside the water is (Take acceleration due to gravity as 10 m/s^2, and neglect the effect of viscous forces)

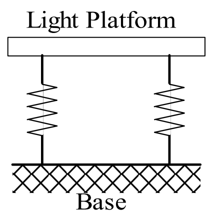
1) 200 J 2) 600 J 3) 400 J 4) 800 J

2. A car starts from rest and travels forward with constant acceleration which of the following is correct

1) The power delivered by the drive shaft to the wheel is constant
2) The power delivered by the drive shaft to the wheels increases as the car gains speed
3) The KE of the car is proportional to the time
4) The power delivered by the drive shaft to the wheels decreases as the car gains speed

3. A force of 1 N acts upon a mass of 1 kg for 1 second and gives it a momentum P_1 and kinetic energy E_1. The same force acts upon the same mass for a displacement of 1 m and gives it a momentum P_2 and kinetic energy E_2. Then, which of the following is correct?
1) $P_1 = P_2, E_1 = E_2$ 2) $P_1 > P_2, E_1 > E_2$
3) $P_1 < P_2, E_1 < E_2$ 4) $P_1 > P_2, E_1 < E_2$

4. A pair of identical light elastic springs support a mass less platform as shown in the figure. When a piece of clay of mass 0.1 kg falls on the platform from a height of 0.24 m and sticks to it, the compression in the spring is 0.01 m. The height in meters from which the same piece of clay has to fall to create a compression of 0.04 m is



1) 0.96 2) 1.04 3) 4.00 4) 3.96

5. An outfielder throws a cricket ball with an initial kinetic energy of 800 J and an infielder at the same level catches the ball when its kinetic energy is 600 J. If the path of the ball between them is assumed straight and is 20 m long, the air resistance acting on the ball is
1) 26.6 N 2) 1.33 N 3) 100 N 4) 10 N

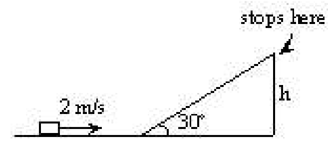
6. A rough inclined plane is 5 m long and 3 m high. A block of mass 6 kg is moved from the foot of the inclined plane to the top. If the coefficient of friction between the block and inclined plane is 0.5, the work done in this movement
1) 30 J 2) 15 J 3) 196 J 4) 294 J

7. The gravitational potential difference between the surface of a planet and a point 10 m above it is 20 J/kg. The work done in moving a 2 kg mass by 10 m on a smooth inclined surface making 30° with the horizontal is
1) 100 J 2) 200 J 3) 20 J 4) 2 J

8. Water flows out horizontally from a hose with a velocity of 20 m s^{-1}. The area of cross section of the hose is 2.5×10^{-3} m^2. Density of water is 1000 kg m^{-3}. Power needed to produce the kinetic energy of water is
1) 2.5 kW 2) 20 kW 3) 1 kW 4) 10 kW

9. The kinetic energy of a moving body is given by $K = 2v^2$, K being in joules and v in m/s. It's momentum when traveling with a velocity of 2 m s^{-1} will be
1) 16 kg m s^{-1} 2) 4 kg m s^{-1}
3) 8 kg m s^{-1} 4) 2 kg m s^{-1}

10. A block sliding along a horizontal frictionless surface with a velocity of 2 m s^{-1} comes to the bottom of a frictionless inclined plane making an angle of 30° with the horizontal and comes to a stop after ascending the inclined plane as indicated. If g = 10 m s^{-2}, the value of 'h' is



1) 5 m 2) 10 m 3) 0.2 m 4) 2 m

11. A small sphere of mass M is dropped from a great height, After it has fallen 100 m, it has attained its terminal velocity and continues to fall at that speed. The work done by air friction against the sphere during the first 100 m of fall is (g = acceleration due to gravity)
1) greater than the work done by air friction in the second 100 m
2) less than the work done by air friction in the second 100 m
3) equal to 100 Mg
4) greater than 100 Mg

12. A train of mass "M" is driven with acceleration "a" along a straight level track against a constant external resistance "R". When the velocity of the train is "v", the rate at which the engine of the train is doing work will be
1) R v 2) M a V
3) (R + M a)v 4) (Ma – R) v

13. An empty truck moving on a straight road with a certain velocity can be stopped over a distance "s" by applying the brakes. If the truck is loaded so that its mass now is one and half times that of the empty truck and is moving with the same velocity, it can be stopped by the brakes in a distance of (assume that the same braking force is acting in the two cases)
1) s/2 2) 2 s 3) 3s/2 4) 2s/3

14. A lifting machine, having an efficiency of 80 % uses 2500 J of energy in lifting a 10 kg load over a certain height. If the load is now allowed to fall through that height freely, its velocity at the end of the fall will be (take acceleration due to gravity as 10 m/s^2)
1) 10 m s^{-1} 2) 15 m s^{-1} 3) 20 m s^{-1} 4) 25 m s^{-1}

15. A body is projected vertically up from a point on the ground. When it is at a height "h" above the ground, its kinetic and potential energies are found to be in the ratio of 3 : 2. If the body rises to a maximum height of "H" above the ground, then the ratio of H : h will be
1) 5 : 3 2) 2 : 1 3) 5 : 2 4) 2 : 5

16. A small cube of mass 'm' slides down a quadrantal circular path of radius 'R' cut into a large block of mass 'M', as shown in the figure. The block rests on a table, and both cube and block move without friction. The cube and block are initially at rest, and the cube starts from the top of the path. The velocity of the cube as it leaves the block is

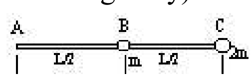
1) $\sqrt{2gR}$ 2) $\sqrt{\frac{2gR(M+m)}{(M+2m)}}$

3) $\sqrt{\frac{2gRM}{M+m}}$ 4) $\sqrt{\frac{2gR(M+2m)}{(M+m)}}$

17. An engine developing an average power of 1500 kW applies a steady force for 4 minutes on a train moving with a velocity of 10 m s^{-1}. If there is no friction and the velocity attained by the train is 20 m s^{-1}, the mass of the train must be
1) 240 tonnes 2) 24 tonnes
3) 2400 tonnes 4) 2.4 tonnes

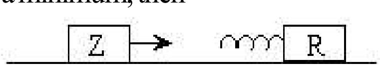
18. A block of mass 150 kg is taken along a rough inclined plane on to the top of a platform which is at a height of 4 m above the ground level. If the force of friction between the surface of the plane and the block is 100 N and the length of the inclined plane is 10 m, the work done in pushing the body to the top is (Take acceleration due to gravity as 10 m s^{-2})
1) 6000 J 2) 1000 J 3) 7000 J 4) 3500 J

19. A long rod ABC of mass "m" and length "L" has two particles of masses "m" and "2m" attached to it as shown in the figure. The system is initially in the horizontal position. The work to be done to keep it vertical with A at the bottom is (g = acceleration due to gravity)



1) 2mgL 2) 3mgL/2 3) 5mgL/2 4) 3mgL

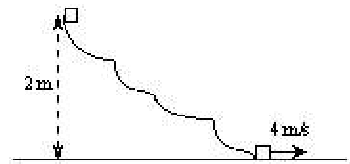
20. A block Z of mass 1.5 kg approaches and collides with another block R of mass 2.0 kg. See the accompanying diagram. Block R has a spring attached to it and it is initially at rest. When the separation between the blocks has reached a minimum, then



1) block R is still at rest
2) block Z has come to rest
3) both blocks have the same momentum
4) the kinetic energy of the system has reached a minimum

21. A mass less spring with a force constant K = 40 N/m hangs vertically from the ceiling. A 0.2 kg block is attached to the free end of the spring and held in such a position that the spring has its natural length and suddenly released. The maximum elastic strain energy stored in the spring is(take g = 10 m/s^2)
1) 0.1 J 2) 0.2 J 3) 0.05 J 4) 0.4 J

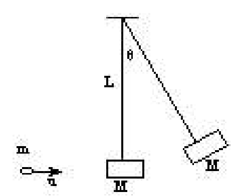
22. A block of mass 0.4 kg slides down an irregular path as shown and reaches the bottom with a velocity of 4 m/s. If during the journey the block has fallen through a vertical height of 2 m, the work done by the force of friction on the block is (g = 10 ms^{-2})



1) 3.8 J 2) 4.8 3) 8 J 4) 3.2 J

23. A carpet of mass 'm' is rolled along its length in the form of a cylinder of radius 'R' and is kept on a rough floor. When a small push is given, the carpet starts unrolling without slipping on the floor. The kinetic energy of the carpet, when the radius is reduced to 'R/2' will be
1) 3mgR/42) mgR/4 3) 7mgR/8 4) mgR/8

24. A bullet of mass 'm' is fired in to the suspended wooden block of mass 'M' and gets embedded in it and the string of length 'L' swings through an angle θ after impact before swinging back. The speed of the bullet 'u' is (g = acceleration due to gravity)



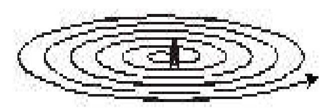
1) $\frac{(M+m)}{m}\sqrt{2gL(1-\cos\theta)}$

2) $\frac{m}{(M+m)}\sqrt{2gL(1-\cos\theta)}$

3) $\frac{(M+m)}{m}\sqrt{2gL(1-\sin\theta)}$

4) $\frac{m}{(M+m)}\sqrt{2gL(1-\sin\theta)}$

25. A cable in the form of a spiral roll as shown in the figure has a linear density 0.25 kg/m. It is uncoiled at a uniform speed of 2 m/s. If the total length of the cable is 15 m, the work done in uncoiling is (neglect friction)



1) 15 J 2) 7.5 J 3) 30 J 4) 3.75 J

26. Two bodies of masses 'm_1' and 'm_2' are moving with velocities 'v_1' and 'v_2' respectively in the same direction. The kinetic energy of the system in the frame of reference attached to their center of mass is (v is relative velocity between the masses)

1) $\frac{1}{2}\left(\frac{m_1 m_2}{m_1+m_2}\right)v^2$ 2) $\left(\frac{m_1 m_2}{m_1+m_2}\right)v^2$

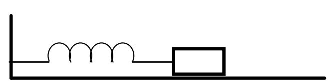
3) $\left(\frac{2m_1 m_2}{m_1+m_2}\right)v^2$ 4) $\frac{1}{4}\left(\frac{m_1 m_2}{m_1+m_2}\right)v^2$

27. A carpet of mass 'm' is rolled along its length in the form of a cylinder of radius 'R' and is kept on a rough floor. When a small push is given, the carpet starts unrolling without slipping on the floor. The velocity of the centre of the roll of the carpet, when the radius is reduced to 'R/2' will be

1) $\sqrt{7gR/6}$ 2) $\sqrt{7gR/4}$

3) $\sqrt{14gR/3}$ 4) $\sqrt{7gR}$

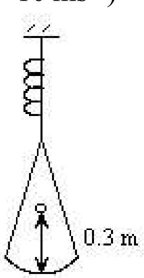
28. A mass attached to a horizontal mass less spring is displaced 16 cm to the right of its equilibrium position (see accompanying figure) and released from rest. At its 16 cm extension, the spring-mass system has 1.28 joules of potential energy. Upon release, it slides across a rough surface and comes momentarily to rest 8 cm to the left of its equilibrium position. How much mechanical energy was dissipated by friction?



Rough horizontal surface

1) 0.16 J 2) 0.32 J 3) 0.64 J 4) 0.96 J

29. A plastic pan of mass 0.2 kg when suspended from a mass less spring extends by 0.1 m. A lump of clay of mass 0.2 kg is dropped from rest on to the pan from a height of 0.3 m as shown in the figure. As a result, the pan moves downward through a maximum distance of (g = 10 ms^{-2})



1) 0.2 m 2) 0.3 m 3) 0.4 m 4) 0.1 m

30. A goods train moves steadily on a level track with a velocity 108 kph. Snow falls vertically on to it, and accumulates at a constant rate of 10 kg s^{-1}. The additional power required in order to maintain the train's speed despite the snow is

1) 4.5 kW 2) 9.0 kW
3) 18.0 kW 4) 2.25 kW

31. A running man has half the kinetic energy that a running boy of half his mass has. The man speeds up by 1.0 m/s and now has the same kinetic energy as the boy. The original speed of the man expressed in m/s units must be

1) $\sqrt{2}+1$ 2) $\sqrt{2}-1$ 3) $2+\sqrt{2}$ 4) $2-\sqrt{2}$

32. A chain of mass 'm' and length 'L' is over hanging from the edge of a smooth horizontal table such that 1/n th of its length is lying on the table. The work done in pulling the chain completely on to the table is

1) $\frac{mgL}{2n^2}$ 2) $\frac{mgL(n-1)^2}{2n^2}$

3) $\frac{mgL(n-1)^2}{n^2}$ 4) $\frac{mgL}{n^2}$

KEY

1) 3	2) 2	3) 3	4) 4	5) 4	6) 4
7) 3	8) 4	9) 3	10) 3	11) 2	12) 3
13) 3	14) 3	15) 3	16) 2	17) 3	18) 3
19) 4	20) 4	21) 2	22) 2	23) 3	24) 1
25) 2	26) 1	27) 3	28) 4	29) 2	30) 2
31) 1	32) 2				

WORK, POWER AND ENERGY NEW MODEL QUESTIONS

In the following questions, a statement of Assertion
(A) is followed by a statement of Reason(R). Of these statements, select the correct answer according to the scheme given below.
1) Both A and R are individually true and R is the correct explanation of A
2) Both A and R are individually true but R is not the correct explanation of A
3) A is true but R is false
4) Both A and R are false

1. Assertion (A): The work done by the centripetal force on a body in uniform circular motion is zero.
Reason (R): In uniform circular motion, the force and displacement are always perpen- dicular to each other.

2. Assertion (A): A spring has potential energy, both when it is compressed or stretched.
Reason (R): In compressing or stretching, work is done on the spring against the restoring force developed in it.

3. Assertion (A): Force acting on a body is not zero and the displacement of the body under the action

of that force is also not zero, yet the work done can be zero.

Reason (R): Work not only depends on the force and displacement but also on the cosine of the angle between the force direction and displacement direction.

4. Assertion (A): When an apple is projected vertically upward from the ground, the work done by gravity force while it is rising is negative and the work done by gravity force while it is falling is positive.

Reason (R): Work done by a force is independent of the direction of displacement.

5. Assertion (A): When a body is dragged along a rough horizontal surface, the work done by the frictional force is negative

Reason (R): The frictional force on the dragged body is opposite to the displacement caused in it.

6. Assertion (A): The gravitational potential energy of a two body system is always negative

Reason (R): When attraction forces are present, the work done in bringing the bodies from infinity to their final positions by an external agent is negative.

7. Assertion (A): The law of conservation of mechanical energy is invalid when friction like forces, are present.

Reason (R): Friction converts some of the mechanical energy to thermal energy.

8. Assertion (A): According to work energy theorem, the work done by the resultant force on a system is equal to change in the kinetic energy of that system and is true only when friction like forces, are absent.

Reason (R): Frictional force is a conservative force and its presence violates the work energy theorem.

9. Assertion (A): When a road roller is pulled by you the work done positive and when it is pushed by you, the work done is negative.

Reason (R): Work done by a force being a scalar cannot take negative values.

10. Assertion (A): Force and velocity are vectors and the instantaneous power is a scalar. Therefore, instantaneous power is the dot product of force and velocity.

Reason (R): The dot product of two vectors is a scalar.

KEY

1) 1	2) 1	3) 1	4) 3	5) 1
6) 1	7) 1	8) 4	9) 4	10) 1

PREVIOUS EAMCET QUESTIONS

1. When a body of mass 1.0 kg is suspended from a certain light spring hanging vertically, its length increases by 5 cm. By suspending 2.0 kg block to the spring and if the block is pulled through 10 cm and released, the maximum velocity in it in m/s is (Acceleration due to gravity = 10 m/s^2)[2003 ENG]

1) 0.5 2) 1 3) 2 4) 4

2. A body of mass 'm' has a kinetic energy equal to one-fourth kinetic of another body of mass $m/4$. If the speed of the heavier body is increased by 4 m/s, its new kinetic energy equals the original kinetic energy of the lighter body. The original speed of the heavier body in m/s is: [2003 MED]

1) 8 2) 6 3) 4 4) 2

3. A block of mass 2 kg is initially at rest on a horizontal frictionless surface. A horizontal force $\overline{F} = (9 - x^2)\,\overline{i}$ newtons acts on it, when the block is at $x = 0$. The maximum kinetic energy of the block between $x = 0$ and $x = 3$ m in joules is: [2004 ENG]

1) 24 2) 20 3) 18 4) 15

4. A machine gun fires 240 bullets per minute . If the mass of each bullet is 10 g and the velocity of the bullets is 600 ms^{-1} , the power (in kW) of the gun is: [2005 ENG]

(1) 43200 (2) 432 (3) 72 (4) 7.2

5. A nucleus of mass 218 amu in free state decays to emit an α–particle. Kinetic energy of the α–particle emitted is 6.7 MeV. The recoil energy (in MeV) of the daughter nucleus is [2005 MED]

1) 1.0 2) 0.5 3) 0.25 4) 0.125

KEY

1) 2	2) 3	3) 3	4) 4
5) 4			

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