WORK, ENERGY AND POWER

FACT/DEFINITION TYPE QUESTIONS

1. No work is done if
   (a) displacement is zero
   (b) force is zero
   (c) force and displacement are mutually perpendicular
   (d) All of these
2. The magnitude of work done by a force
   (a) depends on frame of reference
   (b) does not depend on frame of reference
   (c) cannot be calculated in non-inertial frames.
   (d) both (a) and (b)
3. Work is always done on a body when
   (a) a force acts on it
   (b) it moves through a certain distance
   (c) it experiences an increase in energy through a mechanical influence
   (d) None of these
4. A boy carrying a box on his head is walking on a level road from one place to another is doing no work. This statement is
   (a) correct (b) incorrect
   (c) partly correct (d) cannot say
5. When the force retards the motion of body, the work done is
   (a) zero
   (b) negative
   (c) positive
   (d) Positive or negative depending upon the magnitude of force and displacement
6. In which of the following work is being not done?
   (a) Shopping in the supermarket
   (b) Standing with a basket of fruit on the head
   (c) Climbing a tree
   (d) Pushing a wheel barrow
7. A man pushes a wall and fails to displace it, he does
   (a) negative work
   (b) positive but not maximum work
   (c) no work at all
   (d) maximum positive work
8. According to work-energy theorem, the work done by the net force on a particle is equal to the change in its
   (a) kinetic energy (b) potential energy
   (c) linear momentum (d) angular momentum
9. A light and a heavy body have equal momentum. Which one has greater K.E.?
   (a) The lighter body
   (b) The heavier body
   (c) Both have equal K.E.
   (d) Data given is incomplete
10. A particle of mass m has momentum p. Its kinetic energy will be
    (a) mp (b) p^2m
    (c) $\frac{p^2}{m}$ (d) $\frac{p^2}{2m}$
11. Kinetic energy, with any reference, must be
    (a) zero (b) positive
    (c) negative (d) both (b) and (c)
12. Total ....*X*.... energy of a system is conserved, if the forces, doing work on it, are .....*Y*..... .
    Here, *X* and *Y* refer to
    (a) conservative, mechanical
    (b) mechanical, conservative
    (c) mechanical, non-conservative
    (d) kinetic, conservative
13. A bullet is fired and gets embedded in block kept on table. If table is frictionless, then
    (a) kinetic energy gets conserved
    (b) potential energy gets conserved
    (c) momentum gets conserved
    (d) both (a) and (c)
14. Unit of energy is
    (a) kwh (b) joule
    (c) electron volt (d) All of these
15. Which of the following is not a conservative force?
    (a) Gravitational force (b) Frictional force
    (c) Spring force (d) None of these
16. If a light body and heavy body have same kinetic energy, then which one has greater linear momentum?
    (a) Lighter body (b) Heavier body
    (c) Both have same momentum (d) Can't be predicted

17. The time rate of change of kinetic energy is equal to

(a) $\frac{1}{2}m\frac{dv}{dt}$ (b) $m\frac{dv}{dt}v$

(c) $m\frac{dv}{dt}$ (d) $\frac{1}{2}mv\frac{dv}{dt}$

18. Two bodies of different masses are moving with same kinetic energy. Then the ratio of their momenta is equal to the ratio of their

(a) masses (b) square of masses

(c) square root of masses (d) cube root of masses

19. A spring with force constant k is initially stretched by x_1. If it is further stretched by x_2, then the increase in its potential energy is

(a) $\frac{1}{2}k(x_2 - x_1)^2$ (b) $\frac{1}{2}kx_2(x_2 + 2x_1)$

(c) $\frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2$ (d) $\frac{1}{2}k(x_1 + x_2)^2$

20. The speed of an object of mass *m* dropped from an inclined plane (frictionless), at the bottom of the plane, depends on:

(a) height of the plane above the ground

(b) angle of inclination of the plane

(c) mass of the object

(d) All of these

21. A particle is taken round a circle by application of force. The work done by the force is

(a) positive non–zero (b) negative non–zero

(c) Zero (d) None of the above

22. Four particles given, have same momentum. Which has maximum kinetic energy

(a) Proton (b) Electron

(c) Deutron (d) α-particles

23. The potential energy of a system increases if work is done

(a) upon the system by a non conservative force

(b) by the system against a conservative force

(c) by the system against a non conservative force

(d) upon the system by a conservative force

24. The temperature at the bottom of a high water fall is higher than that at the top because

(a) by itself heat flows from higher to lower temperature

(b) the difference in height causes a difference in pressure

(c) thermal energy is transformed into mechanical energy

(d) mechanical energy is transformed into thermal energy.

25. If two particles are brought near one another, the potential energy of the system will

(a) increase (b) decrease

(c) remains the same (d) equal to the K.E

26. Which of the following is correct?

(a) $W = FS\cos\theta$

(b) P. E. = mgh

(c) K. E. = $\frac{1}{2}mv^2$

(d) All of these

27. Work done by a conservative force is positive if

(a) P.E. of the body increases

(b) P.E. of the body decreases

(c) K.E. of the body increases

(d) K.E. of the body decreases

28. The potential energy of a system increases if work is done

(a) upon the system by a non conservative force

(b) by the system against a conservative force

(c) by the system against a non conservative force

(d) upon the system by a conservative force

29. The ...*X*... energy *V*(*x*) of the spring is said to be zero when block and spring system is in the ...*Y*... position.

Here, *X* and *Y* refer to

(a) potential, equilibrium

(b) kinetic, equilibrium

(c) mechanical, equilibrium

(d) vibrational, left

30. For a conservative force in one dimension, potential energy function V(x) is related to the force F(x) as

(a) $F(x) = \frac{-dV(x)}{dx}$ (b) $F(x) = \frac{dV(x)}{dx}$

(c) $F(x) = V(x)dx$ (d) $F(x) = \int \frac{-dV(x)}{dx}$

31. The total mechanical energy of a system is conserved if the force, doing work on it is

(a) constant (b) variable

(c) conservative (d) non-conservative

32. If stretch in a spring of force constant k is doubled then the ratio of elastic potential energy in the two cases will be

(a) 4 : 1 (b) 1 : 4

(c) 2 : 1 (d) 1 : 2

33. The energy stored in wounded spring watch is

(a) Kinetic (b) Potential

(c) Heat (d) chemical

34. The work done in stretching a spring of force constant k from length ℓ_1 and ℓ_2 is

(a) $k(\ell_2^2 - \ell_1^2)$ (b) $\frac{1}{2}k(\ell_2^2 - \ell_1^2)$

(c) $k(\ell_2 - \ell_1)$ (d) $\frac{k}{2}(\ell_2 + \ell_1)$

35. Which of the following force(s) is/are non-conservative?

(a) Frictional force (b) Spring force

(c) Elastic force (d) All of these

36. Law of conservation of energy states that

(a) work done is zero

(b) energy is zero

(c) work done is constant

(d) energy of world is constant

37. If a force F is applied on a body and it moves with a velocity V, the power will be

(a) F×v (b) F/v

(c) F/v^2 (d) $F \times v^2$

38. Unit of power is

(a) kilowatt hour (b) kilowatt/hour

(c) watt (d) erg

39. Which of the following must be known in order to determine the power output of an automobile?
(a) Final velocity and height
(b) Mass and amount of work performed
(c) Force exerted and distance of motion
(d) Work performed and elapsed time of work

40. If a shell fired from a cannon, explodes in mid air, then
(a) its total kinetic energy increases
(b) its total momentum increases
(c) its total momentum decreases
(d) None of these

41. Which one of the following statements is true?
(a) Momentum is conserved in elastic collisions but not in inelastic collisions
(b) Total kinetic energy is conserved in elastic collisions but momentum is not conserved in elastic collisions
(c) Total kinetic energy is not conserved but momentum is conserved in inelastic collisions
(d) Kinetic energy and momentum both are conserved in all types of collisions

42. When after collision the deformation is not relived and the two bodies move together after the collision, it is called
(a) elastic collision
(b) inelastic collision
(c) perfectly inelastic collision
(d) perfectly elastic collision

43. In an inelastic collision, which of the following does not remain conserved?
(a) Momentum
(b) kinetic energy
(c) Total energy
(d) Neither momentum nor kinetic energy

44. The coefficient of restitution e for a perfectly elastic collision is
(a) 1 (b) 0
(c) ∞ (d) -1

45. The coefficient of restitution e for a perfectly inelastic collision is
(a) 1 (b) 0
(c) ∞ (d) -1

46. When two bodies stick together after collision, the collision is said to be
(a) partially elastic (b) elastic
(c) inelastic (d) perfectly inelastic

47. Consider the elastic collision of two bodies A and B of equal mass. Initially B is at rest and A moves with velocity v. After the collision
(a) the body A traces its path back with the same speed
(b) the body A comes to rest and B moves away in the direction of A's approach with the velocity v
(c) both the bodies stick together and are at rest
(d) B moves along with velocity v/2 and A retraces its path with velocity v/2.

48. The principle of conservation of linear momentum can be strictly applied during a collision between two particles provided the time of impact
(a) is extremely small
(b) is moderately small
(c) is extremely large
(d) depends on particular case

49. In a one-dimensional elastic collision, the relative velocity of approach before collision is equal to
(a) sum of the velocities of the bodies
(b) e times the relative velocity of separation after collision
(c) 1/e times the relative velocity of separation after collision
(d) relative velocity of separation after collision

50. In case of elastic collision, at the time of impact.
(a) total K.E. of colliding bodies is conserved.
(b) total K.E. of colliding bodies increases
(c) total K.E. of colliding bodies decreases
(d) total momentum of colliding bodies decreases.

51. When two spheres of equal masses undergo glancing elastic collision with one of them at rest, after collision they will move
(a) opposite to one another
(b) in the same direction
(c) together
(d) at right angle to each other

52. In an inelastic collision
(a) momentum is not conserved
(b) momentum is conserved but kinetic energy is not conserved
(c) both momentum and kinetic energy are conserved
(d) neither momentum nor kinetic energy is conserved

53. In an elastic collision, what is conserved ?
(a) Kinetic energy (b) Momentum
(c) Both (a) and (b) (d) Neither (a) nor (b)

54. In elastic collision, 100% energy transfer takes place when
(a) $m_1 = m_2$ (b) $m_1 > m_2$
(c) $m_1 < m_2$ (d) $m_1 = 2m_2$

STATEMENT TYPE QUESTIONS

55. Choose the correct statement(s) from the following.
I. No work is done if the displacement is perpendicular to the direction of the applied force
II. If the angle between the force and displacement vectors is obtuse, then the work done is negative
III. All the central forces are non-conservative
(a) I only (b) I and II
(c) II and III (d) I, II and III

56. Consider the following statements and select the incorrect statement(s).
I. If work is done on a body against some force, then kinetic energy has to change.
II. No work done on earth by sun when it revolves around the sun in a perfectly circular orbit
III. K.E. can never be negative
(a) I only (b) II only
(c) I and II (d) I, II and III

57. Which of the following statement(s) is/are correct?

I. K.E. of a system can be changed without changing its momentum

II. Momentum of a system can be changed without changing its K.E.

(a) I only (b) II only

(c) I and II (d) None of these

58. Which of the following statements are incorrect for an oscillating spring?

I. Kinetic energy is maximum at the extreme position

II. Kinetic energy is minimum at the extreme position

III. Potential energy is maximum at equilibrium position

(a) I and II (b) II and III

(c) I and III (d) I, II and III

59. Identify the correct statement(s) from the following.

I. Work-energy theorem is not independent of Newton's second law.

II. Work-energy theorem holds in all inertial frames.

III. Work done by friction over a closed path is zero.

(a) I only (b) II and III

(c) I and II (d) I, II and III

60. Which of the following statements are incorrect ?

I. If there were no friction, work need to be done to move a body up an inclined plane is zero.

II. If there were no friction, moving vehicles could not be stopped even by locking the brakes.

III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.

IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.

(a) I and II (b) I, II and IV

(c) I, III and IV (d) I, II, III and IV

61. A force $F(x)$ is conservative, if

I. it can be derived from a scalar quantity $V(x)$.

II. it depends only on the end points.

III. work done by $F(x)$ in a closed path is zero.

Which of the following option is correct ?

(a) Only I (b) I and III

(c) Only II (d) I, II and III

62. Choose the correct conversion taking place in the generation of electricity by burning of coal in a thermal station in all the stages.

I. Chemical energy to heat energy

II. Heat energy to mechanical energy

III. Mechanical energy to electrical energy

(a) II and III (b) I and II

(c) I and III (d) I, II and III

63. Consider the following statements and select the correct statements.

I. Work energy theorem is a scalar form of Newton's second law.

II. Conservation of mechanical energy is a consequence of work energy theorem for conservative forces

III. Work energy theorem holds in all inertial frames

(a) I and II (b) II and III

(c) I and III (d) I, II and III

64. In elastic collision,

I. initial kinetic energy is equal to the final kinetic energy.

II. kinetic energy during the collision time Δt is constant.

III. total momentum is conserved.

Which of the above statements is/are correct ?

(a) Only I (b) I and III

(c) Only III (d) Only II

MATCHING TYPE QUESTIONS

65. A small block of mass 200g is kept at the top of a an incline which is 10 *m* long and 3.2 *m* high. Match the columns

Column I	Column II
(A) Work done, to lift the block from the ground and put it at the top	(1) 6.4 J
(B) Work done to slide the block up the incline	(2) 7.2 J
(C) the speed of the block at the ground when left from the top of the incline to fall vertically	(3) 4 m/s
(D) The speed of the block at the ground when side along the incline	(4) 8 m/s

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)

(b) (A)→(1); (B)→(1); C→(3); (D)→(3)

(c) (A)→(4); (B)→(3); C→(2); (D)→(2)

(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

66. If W represents the work done, then match the two columns:

Column I	Column II
(A) Force is always along the velocity	(1) $W = 0$
(B) Force is always perpendicular to velocity	(2) $W < 0$
(C) Force is always perpendicular to acceleration	(3) $W > 0$
(D) The object is stationary but the point of application of the force moves on the object	

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)

(b) (A)→(3); (B)→(1); C→(2,3); (D)→(1)

(c) (A)→(2); (B)→(3); C→(1); (D)→(2)

(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

67. Column I represents work done by forces and column II represents change in kinetic energy Δk, change in potential energy ΔU, change in mechanical energy ΔE. Then match the two columns

Column I	Column II (magnitude only)
(A) Work done by conservative force	(1) ΔK
(B) Work done by non-conservative force	(2) ΔU
(C) Work done by internal force	(3) ΔE
(D) Work done by external force	

(a) (A)→(1,2); (B)→(1,2); C→(1,2); (D)→(1,3)
(b) (A)→(3); (B)→(1); C→(1,2); (D)→(3)
(c) (A)→(3); (B)→(2); C→(1); (D)→(2,3)
(d) (A)→(1,3); (B)→(2,3); C→(2); (D)→(1)

68.

Column I	Column II
(A) Kinetic energy	(1) Drilling a nail
(B) Potential energy	(2) Water tank on the roof
(C) Mechanical energy	(3) Pushing a wall
(D) Muscular energy	(4) Motion of a car

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(2); C→(1); (D)→(3)
(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

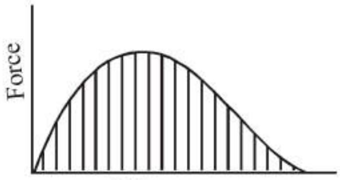
69.

Column I	Column II
(A) Kinetic Energy	(1) Stretched spring
(B) Potential Energy	(2) Watt
(C) Collision	(3) Elastic or inelastic
(D) Power	(4) A boy running on the roof

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(4); (B)→(1); C→(3); (D)→(2)

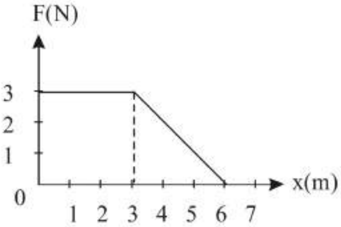
DIAGRAM TYPE QUESTIONS

70. Which one of the following physical quantities is represented by the shaded area in the given graph?



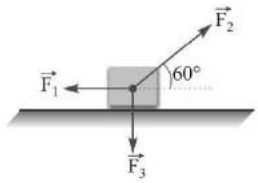
(a) Torque (b) Impulse
(c) Power (d) Work done

71. A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is



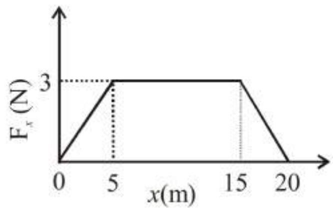
(a) 18.0 J (b) 13.5 J
(c) 9.0 J (d) 4.5 J

72. Figure shows three forces applied to a trunk that moves leftward by 3 m over a smooth floor. The force magnitudes are $F_1 = 5N$, $F_2 = 9N$, and $F_3 = 3N$. The net work done on the trunk by the three forces



(a) 1.50 J (b) 2.40 J
(c) 3.00 J (d) 6.00 J

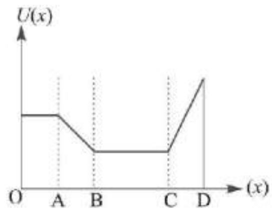
73. A force F_x acts on a particle such that its position x changes as shown in the figure.



The work done by the particle as it moves from x = 0 to 20 m is

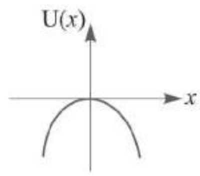
(a) 37.5 J (b) 10 J
(c) 45 J (d) 22.5 J

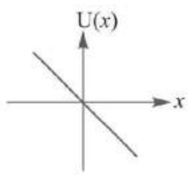
74. The figure gives the potential energy function $U(x)$ for a system in which a particle is in one-dimensional motion. In which region the magnitude of the force on the particle is greatest :

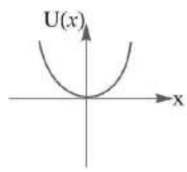


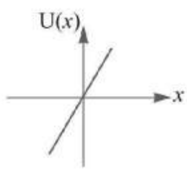
(a) *OA* (b) *AB*
(c) *BC* (d) *CD*

75. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is positive constant). If $U(0) = 0$, the graph of $U(x)$ versus x will be (where U is the potential energy function) :

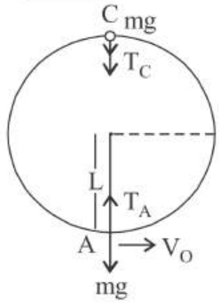
(a)


(b)


(c)


(d)


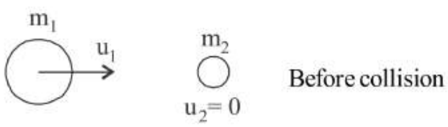
76. Figure shows a bob of mass *m* suspended from a string of length L. The velocity is V_0 at A, then the potential energy of the system is ________ at the lowest point A.

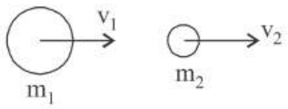


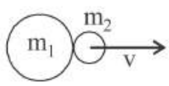
(a) $\frac{1}{2}mv_0^2$ (b) mgh

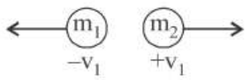
(c) $\frac{-1}{2}mv_0^2$ (d) zero

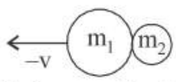
77. For the given case which figure is correctly showing the after inelastic collision situation?



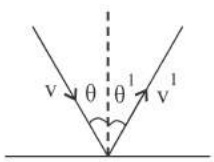
(a)


(b)


(c)


(d)


78. A ball of mass *m* hits the floor making an angle θ as shown in the figure. If e is the coefficient of restitution, then which relation is true, for the velocity component before and after collision?



(a) $V^1 \sin\theta = V \sin\theta$ (b) $V^1 \sin\theta' = -\sin\theta$
(c) $V^1 \cos\theta' = V\cos\theta$ (d) $V^1 \cos\theta' = -V\cos\theta$

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

79. **Assertion :** The work done in moving a body over a closed loop is zero for every force in nature.
Reason : Work done depends on nature of force.

80. **Assertion :** A force applied on the body always does work on the body.
Reason : If a force applied on a body displaces the body along the direction of force work done will be maximum.

81. **Assertion :** A man rowing a boat upstream is at rest with respect to the bank. He is doing no external work.
Reason : Work done by constant force, $W = Fs\cos\theta$.

82. **Assertion :** The rate of change of total momentum of a many particle system is proportional to the sum of the internal forces of the system.
Reason : Internal forces can change the kinetic energy but not the momentum of the system.

83. **Assertion :** A work done by friction is always negative.
Reason : If frictional force acts on a body its K.E. may decrease.

84. **Assertion :** The change in kinetic energy of a particle is equal to the work done on it by the net force.
Reason : Change in kinetic energy of particle is equal to workdone only in case of a system of one particle.

85. **Assertion:** Kinetic energy of a body is quadrupled, when its velocity is doubled.
Reason : Kinetic energy is proportional to square of velocity. If velocity is doubled the K.E. will be quadrupled

86. **Assertion:** If the velocity of a body is tripled, then K.E. becomes 9 times.
Reason : Kinetic energy, K.E.= $\frac{1}{2}mv^2$

87. **Assertion:** Kinetic energy of a system can be increased or decreased without applying any external force on the system.
Reason: This is because K.E. = $\frac{1}{2}mV^2$, so it independent of any external forces.

88. 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.
Assertion : If stretched by the same amount work done on S_1
Reason : $k_1 < k_2$

89. **Assertion :** A spring has potential energy, both when it is compressed or stretched.
Reason : In compressing or stretching, work is done on the spring against the restoring force.

90. **Assertion :** Graph between potential energy of a spring versus the extension or compression of the spring is a straight line.
Reason : Potential energy of a stretched or compressed spring, proportional to square of extension or compression.

91. **Assertion:** The P.E. of a spring increases when it is compressed and decreases when it is stretched.
Reason: During compression work is done on the spring while during stretching work is done by the spring.

92. **Assertion :** When a body moves vertically upward, work done by gravitational force is negative.
Reason : According to conservation of mechanical energy, $\Delta K + \Delta U = 0$.

93. **Assertion :** Mechanical energy is the sum of macroscopic kinetic & potential energies.
Reason : Mechanical energy is that part of total energy which always remain conserved.

94. **Assertion :** Mass and energy are not conserved separately, but are conserved as a single entity called mass-energy.
Reason : Mass and energy are inter-convertible in accordance with Einstein's relation.
$$E = mc^2$$

95. **Assertion :** When a machine gun fires n bullets per second each with kinetic energy K, the power of a gun is $P = nK$
Reason : Power P = work done / time

96. **Assertion :** Power developed in circular motion is always zero.
Reason : Work done in case of circular motion is not zero.

97. **Assertion:** Linear momentum is conserved in both elastic and inelastic collisions but total energy is not conserved in inelastic collision.
Reason: Law of conservation of momentum states that momentum has to be conserved in an isolated system.

98. **Assertion :** A point particle of mass m moving with speed υ 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 $f = \left(\frac{m}{M+m}\right)$.
Reason : Maximum energy loss occurs when the particles get stuck together as a result of the collision.

99. **Assertion :** A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical.
Reason : The rate of change of momentum determines that the force is small or large.

100. **Assertion :** If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.
Reason : During collision intermolecular space decreases and hence elastic potential energy increases.

101. **Assertion :** Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.
Reason : Principle of conservation of momentum holds true for all kinds of collisions.

102. **Assertion :** In an elastic collision of two billiard balls, the total kinetic energy is conserved during the short time of collision of the balls (i.e., when they are in contact).
Reason : Energy spent against friction follow the law of conservation of energy.

CRITICAL THINKING TYPE QUESTIONS

103. If a motorcyclist skids and stops after covering a distance of 15 m. The stopping force acting on the motorcycle by the road is 100 N, then the work done by the motorcycle on the road is
(a) 1500 J (b) –1500 J
(c) 750J (d) Zero

104. A ball moves in a frictionless inclined table without slipping. The work done by the table surface on the ball is
(a) positive (b) negative
(c) zero (d) None of these

105. A force acts on a 30 g particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 seconds is
(a) 576mJ (b) 450mJ
(c) 490mJ (d) 530mJ

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

107. The position of a particle of mass 4 g, acted upon by a constant force is given by $x = 4t^2 + t$, where x is in metre and t in second. The work done during the first 2 seconds is
(a) 128 mJ (b) 512 mJ
(c) 576 mJ (d) 144 mJ

108. An athlete in the olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range
(a) 200 J - 500 J (b) 2×10^5 J - 3×10^5 J
(c) 20, 000 J - 50,000 J (d) 2,000 J - 5, 000 J

109. At time $t = 0$s 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
(a) $\sqrt{t}$ (b) constant
(c) t (d) $\frac{1}{\sqrt{t}}$

110. Two bodies of masses 4 kg and 5 kg are moving with equal momentum. Then the ratio of their respective kinetic energies is
(a) 4 : 5 (b) 2 : 1
(c) 1 : 3 (d) 5 : 4

111. A crate is pushed horizontally with 100 N across a 5 m floor. If the frictional force between the crate and the floor is 40 N, then the kinetic energy gained by the crate is
(a) 200 J (b) 240 J
(c) 250 J (d) 300 J

112. 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 (but non-zero) work on each particle.

(d) the magnetic forces are necessarily negligible.

113. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

(a) x^2 (b) e^x

(c) x (d) $\log_e x$

114. A weight hangs freely from the end of a spring. A boy then slowly pushes the weight upwards until the spring becomes slack. The gain in gravitational potential energy of the weight during this process is equal to

(a) the work done by the boy against the force of gravity acting on the weight

(b) the loss of stored energy by the spring minus the work done by the tension in the spring

(c) the work done on the weight by the boy plus the stored energy lost by the spring

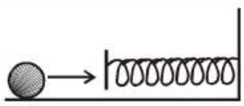
(d) the work done on the weight by the boy minus the work done by the tension in the spring plus the stored energy lost by the spring.

115. A rod of mass m and length l is made to stand at an angle of 60° with the vertical. Potential energy of the rod in this position is

(a) mgl (b) $\frac{mgl}{2}$

(c) $\frac{mgl}{3}$ (d) $\frac{mgl}{4}$

116. A mass of m kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50 N/m. If the maximum compression of the spring is 0.15 m, the value of mass m is



(a) 0.5 kg (b) 0.15 kg

(c) 0.12 kg (d) 1.5 kg

117. A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by

(a) 8.5 cm (b) 5.5 cm

(c) 2.5 cm (d) 11.0 cm

118. Two spring P and Q of force constant k_p and $k_q \left(k_q = \frac{k_p}{2}\right)$ are stretched by applying forces of equal magnitude. If the energy stored in Q is E, then the energy stored in P is

(a) E (b) 2E

(c) E/8 (d) E/2

119. Two springs have their force constant as k_1 and k_2 ($k_1 > k_2$). When they are stretched by the same force

(a) no work is done in case of both the springs.

(b) equal work is done in case of both the springs

(c) more work is done in case of second spring

(d) more work is done in case of first spring.

120. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is $1/2\ k\ x^2$. The possible cases are

(a) the spring was initially compressed by a distance x, was finally in its natural length

(b) it was initially stretched by a distance x and was finally in its natural length

(c) it was initially in its natural length and finally in a compressed position

(d) it was initially in its natural length and finally in the stretched position

121. If the extension in a spring is increased to 4 times then the potential energy

(a) remains the same (b) becomes 4 times

(c) becomes one fourth (d) becomes 16 times

122. Before a rubber ball bounces off from the floor, the ball is in contact with the floor for a fraction of second. Which of the following statements is correct?

(a) Conservation of energy is not valid during this period

(b) Conservation of energy is valid during this period

(c) As ball is compressed, kinetic energy is converted to compressed potential energy

(d) None of these

123. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is

(a) 20 m/s (b) 40 m/s

(c) $10\sqrt{30}$ m/s (d) 10 m/s

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

(a) $\frac{16}{25}$ (b) $\frac{2}{5}$

(c) $\frac{3}{5}$ (d) $\frac{9}{25}$

125. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time is given by

(a) $\frac{mv^2}{T^2}.t^2$ (b) $\frac{mv^2}{T^2}.t$

(c) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$ (d) $\frac{1}{2}\frac{mv^2}{T^2}.t$

126. A vehicle is moving with a uniform velocity on a smooth horizontal road, then power delivered by its engine must be

(a) uniform (b) increasing

(c) decreasing (d) zero

127. The engine of a vehicle delivers constant power. If the vehicle is moving up the inclined plane then, its velocity,

(a) must remain constant

(b) must increase

(c) must decrease

(d) may increase, decrease or remain same.

128. A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest

(a) at the highest position of the body

(b) at the instant just before the body hits the earth

(c) it remains constant all through

(d) at the instant just after the body is projected

129. Johnny and his sister Jane race up a hill. Johnny weighs twice as much as jane and takes twice as long as jane to reach the top . Compared to Jane

(a) Johnny did more work and delivered more power.

(b) Johnny did more work and delivered the same amount of power.

(c) Johnny did more work and delivered less power

(d) Johnny did less work and johnny delivered less power.

130. A body of mass (4m) is lying in x-y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is

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

(c) $2\,mv^2$ (d) $4\,mv^2$

131. A particle of mass m is driven by a machine that delivers a constant power of k watts. If the particle starts from rest the force on the particle at time t is

(a) $\sqrt{mk}\;t^{-1/2}$ (b) $\sqrt{2mk}\;t^{-1/2}$

(c) $\frac{1}{2}\sqrt{mk}\;t^{-1/2}$ (d) $\sqrt{\frac{mk}{2}}t^{-1/2}$

132. If two persons A and B take 2 seconds and 4 seconds respectively to lift an object to the same height *h*, then the ratio of their powers is

(a) 1 : 2 (b) 1 : 1

(c) 2 : 1 (d) 1 : 3

133. If a machine gun fires n bullets per second each with kinetic energy K, then the power of the machine gun is

(a) nK^2 (b) $\frac{K}{n}$

(c) n^2K (d) nK

134. A block of mass $m = 0.1$ kg is connected to a spring of unknown spring constant k. It is compressed to a distance x from its equilibrium position and released from rest. After approaching half the distance $\left(\frac{x}{2}\right)$ from equilibrium position, it hits another block and comes to rest momentarily, while the other block moves with a velocity 3 ms^{-1}. The total initial energy of the spring is

(a) 0.3 J (b) 0.6 J

(c) 0.8 J (d) 1.5 J

135. A particle is moving in a circle of radius r under the action of a force $F = \alpha r^2$ which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy = 0 for r = 0)

(a) $\frac{1}{2}\alpha r^3$ (b) $\frac{5}{6}\alpha r^3$

(c) $\frac{4}{3}\alpha r^3$ (d) αr^3

136. When a body is projected vertically up from the ground with certain velocity, its potential energy and kinetic energy at a point A are in the ratio 2 : 3. If the same body is projected with double the previous velocity, then at the same point A the ratio of its potential energy to kinetic energy is

(a) 9 : 1 (b) 2 : 9

(c) 1 : 9 (d) 9 : 2

137. The total energy of a solid sphere of mass 300 g which rolls without slipping with a constant velocity of 5 ms^{-1} along a straight line is

(a) 5.25 J (b) 3.25 J

(c) 0.25 J (d) 1.25 J

138. A bullet when fired into a target loses half of its velocity after penetrating 20 cm. Further distance of penetration before it comes to rest is

(a) 6.66 cm (b) 3.33 cm

(c) 12.5 cm (d) 10 cm

139. When a rubber-band is stretched by a distance x, it exerts 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

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

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

140. If two equal masses ($m_1 = m_2$) collide elastically in one dimension, where m_2 is at rest and m_1 moves with a velocity u_1, then the final velocities of two masses are

(a) $V_1 = 0; V_2 = u_1$ (b) $V_1 = V_2 = 0$

(c) $V_1 = 0$ and $V_2 = -u_1$ (d) $V_1 = -u_1; V_2 = 0$

141. A particle A suffers an oblique elastic collision with a particle B that is at rest initially. If their masses are the same, then after collision

(a) they will move in opposite directions

(b) A continues to move in the original direction while B remains at rest

(c) they will move in mutually perpendicular directions

(d) A comes to rest and B starts moving in the direction of the original motion of A

142. Which one of the following statements does hold good when two balls of masses m_1 and m_2 undergo elastic collision?

(a) When $m_1 < m_2$ and m_2 at rest, there will be maximum transfer of momentum

(b) When $m_1 > m_2$ and m_2 at rest, after collision the ball of mass m_2 moves with four times the velocity of m_1

(c) When $m_1 = m_2$ and m_2 at rest, there will be maximum transfer of K.E.

(d) When collision is oblique and m_2 at rest with $m_1 = m_2$, after collisions the ball moves in opposite direction

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

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

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

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

(a) $m_1 >> m_2$ (b) $m_2 >> m_2$

(c) $m_1 = m_2$ (d) $m_1 = 2m_2$

145. A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after the collision, the two balls move together, the loss in kinetic energy due to collision is

(a) 140 J (b) 100 J

(c) 60 J (d) 40 J

146. A ball moving with velocity 2 m/s collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in m/s) after collision will be

(a) 0, 1 (b) 1, 1

(c) 1, 0.5 (d) 0, 2

147. A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to mass of 3m moving vertically upward (along the y-axis) with velocity 2v. The final velocity of the combination is

(a) $\frac{1}{4}v\hat{i} + \frac{3}{2}v\hat{j}$ (b) $\frac{1}{3}v\hat{i} + \frac{2}{3}v\hat{j}$

(c) $\frac{2}{3}v\hat{i} + \frac{1}{3}v\hat{j}$ (d) $\frac{3}{2}v\hat{i} + \frac{1}{4}v\hat{j}$

148. A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is

(a) 0.16 J (b) 1.00 J

(c) 0.67 J (d) 0.34 J

149. Two particles A and B, move with constant velocities $\vec{v}_1$ and $\vec{v}_2$. At the initial moment their position vectors are $\vec{r}_1$ and $\vec{r}_2$ respectively. The condition for particles A and B for their collision is

(a) $\vec{r}_1 . \vec{v}_1 = \vec{r}_2 . \vec{v}_2$

(b) $\vec{r}_1 \times \vec{v}_1 = \vec{r}_2 \times \vec{v}_2$

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

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

150. On a frictionless surface a block of mass M moving at speed v collides elastically with another block of same mass M which is initially at rest. After collision the first block moves at an angle θ to its initial direction and has a speed $\frac{v}{3}$. The second block's speed after the collision is

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

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

151. A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0. It collides with the ground loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity v_0 is (Take g = 10 ms^{-2})

(a) 20 ms^{-1} (b) 28 ms^{-1}

(c) 10 ms^{-1} (d) 14 ms^{-1}

152. A particle of mass m moving in the x direction with speed 2*v* is hit by another particle of mass 2*m* moving in the *y* direction with speed **v**. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

(a) 56% (b) 62%

(c) 44% (d) 50%

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(d)** $W = FS\cos\theta$

$\therefore$ If $F = 0$; $W = 0$

If $S = 0$; $W = 0$

& if $\theta = 90°$; $\cos 90° = 0$

$\therefore W = 0$.

2. **(a)**

3. **(c)** (i) Since work $W = \vec{F}.\vec{s} = Fs\cos\theta$

If $\theta = 90° \Rightarrow W = 0$, but force is acting on it so option (a) is not correct.

(ii) A person carrying a suit case vertically in his hand walks in a horizontal direction, no work is done, because the angle between the direction of force applied by hand on weight & direction of displacement is 90°. So option (b) is also not correct.

(iii) According to work energy theorem

work done on body = change in kinetic energy of the bod

4. **(a)** When a person carrying load on his head moves over a horizontal road, work done against gravitational force is zero.

5. **(b)**

6. **(b)**

7. **(c)** When a man pushes a wall and fails to displace it, then displacement of wall = 0

$\therefore$ Work done by man $= F \times 0 = 0$

Therefore, man does no work at all.

8. **(a)** Work done by the net force = change in kinetic energy of the particle.

This is according to work energy theorem.

9. **(a)** Since momentum of both bodies are equal

So $p_1 = p_2 \Rightarrow \dfrac{M_1}{M_2} = \dfrac{u_2}{u_1} \Rightarrow u_2 > u_1$ (let $M_1 > M_2$)

so $\dfrac{E_{k_1}}{E_{k_2}} = \dfrac{P_1^2/2M_1}{P_2^2/2M_2} = \dfrac{M_2}{M_1} \Rightarrow E_{k_1} < E_{k_2}$

It means that light body has greater kinetic energy, if they have equal momentum.

10. **(d)** Let the velocity of the particle be v m/s.

Momentum of the particle (p) = mv

Kinetic energy of the particle

$$(E) = \frac{1}{2}mv^2 = \frac{1}{2}.\frac{(mv)^2}{m}$$

$$E = \frac{p^2}{2m}$$

11. **(b)** $K.E = \dfrac{1}{2}mv^2$

It is always positive

12. **(b)** The principle of conservation of total mechanical energy can be stated as, the total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

13. **(c)** Only momentum is conserved. Some kinetic energy is lost when bullet penetrates the block.

14. **(d)** $1\,Kwh = 3.6 \times 10^6\,J$

$1\,ev = 1.6 \times 10^{-19}\,J$

$\therefore$ J, Kwh and ev all are units of energy.

15. **(b)** As work done by frictional force over a closed path is not zero, therefore, it is non-conservative force.

16. **(b)** $E_1 = E_2 \;\therefore\; \dfrac{1}{2}m_1v_1^2 = \dfrac{1}{2}m_2v_2^2$ or $\dfrac{V_2}{V_1} = \sqrt{\dfrac{m_1}{m_2}}$

$$\frac{P_2}{P_1} = \frac{m_2v_2}{m_1v_1} = \frac{m_2}{m_1}\sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{m_2^2 m_1}{m_1^2 m_2}} = \sqrt{\frac{m_2}{m_1}}$$

If $m_2 > m_1$, then $P_2 > P_1$ i.e. heavier body has greater linear momentum.

17. **(b)** $\dfrac{dk}{dt} = \dfrac{d}{dt}\left(\dfrac{mv^2}{2}\right)$

$$= \frac{1}{\cancel{2}}m\cancel{2}v\frac{dv}{dt} = \frac{mdv}{dt}v$$

18. **(c)** Kinetic energy is given by $k.E = \dfrac{p^2}{2m}$

$$\therefore \frac{p_1^2}{2m_1} = \frac{p_2^2}{2m_2}$$

or $\dfrac{p_1}{p_2} = \sqrt{\dfrac{m_1}{m_2}}$

19. **(b)** $P.E$ in case of spring $= \dfrac{1}{2}kx^2$

Increase in potential energy

$$\frac{1}{2}k(x_1 + x_2)^2 - \frac{1}{2}kx_1^2 = \frac{1}{2}k\left(2x_1x_2 + x_2^2\right)$$

$$= \frac{1}{2}kx_2\left(x_2 + 2x_1\right)$$

20. (a) If an object of mass m is released from rest from top of a smooth inclined plane, its speed at the bottom is $\sqrt{2gh}$, independent of angle θ and mass.

21. (c) Displacement of the particle when it takes a complete round the circular path is zero.

∴ Work done = force × displacement

$W = F \times 0 = 0$

Therefore, work done by the force is zero.

22. (b) $E = \frac{P^2}{2m} \therefore E \propto \frac{1}{m}$ [If P = constant]

i.e. the lightest particle will possess maximum kinetic energy and in the given option mass of electron is minimum.

23. (d) When work is done upon a system by a conservative force then its potential energy increases.

24. (d) By the principle of conservation energy

25. (a) 26. (d) 27. (b)

28. (d) When work is done upon a system by a conservative force then its potential energy increases.

29. (a) We define the potential energy V(x) of the spring to be zero when block and spring system is in the equilibrium position.

30. (a) Conservative force is negative gradient of potential

$$F(x) = \frac{-dV(x)}{dx}$$

31. (c) Principle of conservation of energy states that, the total mechanical energy is conserved if the forces doing work on it are conservative.

32. (a) For a given spring, $u = \frac{1}{2}kx^2$

$$\therefore \frac{u_2}{u_1} = \frac{\frac{1}{2}Kx_2^2}{\frac{1}{2}Kx_1^2} = \frac{(2x)^2}{x^2} = 4:1$$

33. (b) The energy stored in spring in the form of elastic potential energy. i.e., $(P.E)_{elastic} = \frac{1}{2}kx^2$

Where x is compression or elongation of spring & k is spring constant.

34. (b) $w = \frac{1}{2}kl_2^2 - \frac{1}{2}kl_1^2 = \frac{1}{2}k\left(l_2^2 - l_1^2\right)$

35. (a)

36. (d) According to the law of conservation of energy the total energy of the world (universe) remains constant.

37. (a)

38. (c) The S.I. unit of power is watt (W)

39. (d) Power is defined as the rate of doing work. For the automobile, the power output is the amount of work done (overcoming friction) divided by the length of time in which the work was done.

40. (a)

41. (c) The law of conservation of momentum is true in all type of collisions, but kinetic energy is conserved only in elastic collision. The kinetic energy is not conserved in inelastic collision but the total energy is conserved in all type of collisions.

42. (c) In a perfectly inelastic collision, the two bodies move together as one body.

43. (b) In an inelastic collision, momentum remains conserved, but K.E is changed.

44. (a) Since $e = \frac{-(v_1 - v_2)}{(u_2 - u_1)} = \frac{\text{-velocity of separation}}{\text{velocity of approach}}$

(i) For perfectly elastic collision $e = 1$

(ii) For perfectly inelastic collision $e = 0$

(iii) For other collision $0 < e < 1$

45. (b) For a perfectly inelastic collision, $e = 0$.

46. (d) When the two bodies stick together after collision, then it is perfectly inelastic collision and in this case, the coefficient of restitution e is equal to zero.

47. (b) When two bodies of equal mass collide head on elastically, their velocities are mutually exchanged.

48. (a) In physics, collision does not means that are particle strike another particle. Infact, two particles may not even touch each other & may still said to be colliding.

The necessary requirements of collision are

(i) A large force for a relatively short time (i.e., an impulse) acts on each colliding particle.

(ii) The motion of the particles (at least one of the particle) is changed abruptly.

(iii) The total momentum (as also the total energy) of particles remains conserved.

49. (d) Coefficient of restitution,

$$e = \frac{-\text{velocity of seperation}}{\text{velocity of approach}}$$

for elastic collision $e = 1$

50. (c)

51. (d) When two spheres of equal masses undergo a glancing elastic collision with one of them at rest, after the collision they will move at right angle to each other.

52. (b) Momentum is conserved but kinetic energy is not conserved.

53. **(c)** In an elastic collision, momentum and K.E. both conserved.

54. **(a)** During elastic collision between two equal masses, the velocities get exchanged. Hence energy transfer is maximum when $m_1 = m_2$.

STATEMENT TYPE QUESTIONS

55. **(d)** A conservative force is that force which is independant of path followed e.g. gravitational force, electrostatic force, etc. All of these are central forces. So, all the central forces are conservative.

56. **(a)** When a body is moved on a rough horizontal surface with a constant velocity, then work is done against friction but K.E. is constant. So, even if work is done on a body by some force, K.E. remains unchanged

57. **(c)** When a bomb explodes; momentum is conserved K.E. changes and in uniform circular motion , K.E remains constant but momentum changes due to change in directions of motion.

58. **(c)** When spring oscillates, its velocity is minimum at the mean position & hence KE is maximum at the equilibrium position.

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

60. **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.

61. **(d)** A force *F*(*x*) is conservative, if it can be derived from a scalar quantity *V*(*x*) by the relation given by eq, $\Delta v = -F(x)\,\Delta x$. The work done by the conservative force depends only on the end points.

This can be seen from the relation,

$W = K_f - K_i = V(X_i) - V(X_f)$

which depends on the end points.

A third definition states that the work done by this force in a closed path is zero. This is once again apparent from Eq. $K_i + v(X_i) = K_f + v(X_f)$, since $X_i = X_f$

62. **(d)** In burning of coal, chemical energy is converted to heat energy.

63. **(d)**

64. **(b)** In elastic collision, total momentum and kinetic energy will remain conserved.

MATCHING TYPE QUESTIONS

65. **(b)** $A \to (1); B \to (1); C \to (3); D \to (3)$

66. **(b)** $(A) \to (3); (B) \to (1); C \to (2,3); (D) \to (1)$

67. **(a)** $(A) \to (1,2); (B) \to (1,2); C \to (1,2); (D) \to (1,3)$

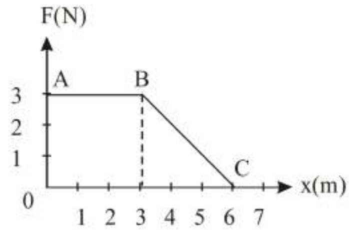
68. **(c)** $(A) \to (4); (B) \to (2); C \to (1); (D) \to (3)$

69. **(d)** $(A) \to (4); (B) \to (1); C \to (3); (D) \to (2)$

DIAGRAM TYPE QUESTIONS

70. **(d)** Work done $= \int Fdx$

71. **(b)**



Work done = area under F-x graph

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

72. **(a)** $\vec{F} = -5\hat{i} + 9\cos 60°\hat{i} + 9\sin 60°\hat{j} - 3\hat{j}$

$= -5\hat{i} + \frac{9}{2}\hat{i} + \frac{9\sqrt{3}}{2}\hat{j} - 3\hat{j}$

$= -\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}$

$\vec{s} = -3\hat{i}$.

$W = \vec{F}.\vec{s} = \left[-\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}\right].(-3\hat{i})$

$= 1.5$ J.

73. **(c)** W = area of $F - x$ graph

= area of Δ + area of rectangle + area of Δ

$= \frac{5 \times 3}{2} + 10 \times 3 + \frac{5 \times 3}{2} = 45\ J$

74. **(d)** $|F| = \frac{dU}{dx}$, which is greatest in the reagion *CD*.

75. **(a)** $U = -\int_0^x Fdx = -\int_0^x kxdx = -\frac{1}{2}kx^2$.

It is correctly drawn in (a)

76. **(d)** At the lowest point, h = 0 ∴ P.E. = 0 (gravitational P.E.). There is no work done on the **bob** by the tension as it is perpendicular to the displacement.

∴ Potential energy is associated only to the gravitational force.

77. **(b)** When $m_1 > m_2$ & m_2 at rest then the bodies collide in elastically and move together as one body without changing the direction.

78. **(a)** As the floor exerts a force on the ball along the normal, & no force parallel to the surface, therefore the velocity component along the parallel to the floor remains constant. Hence $V \sin\theta = V^1 \sin\theta^1$.

ASSERTION- REASON TYPE QUESTIONS

79. **(b)** In close loop, $s = 0$, and so $W = Fs = 0$.

80. **(d)** Work done may be zero, even F is not zero. $W = Fs\cos 0° = Fs$ (maximum).

81. **(a)** In this case, s = 0, and so W = 0.

82. **(d)**

83. **(d)** When frictional force is opposite to velocity, kinetic energy will decrease.

84. **(c)** Change in kinetic energy = work done by net force. This relationship is valid for particle as well as system of particles.

85. **(a)** $K = \frac{1}{2}mv^2 \quad \therefore \quad K \propto v^2$

If velocity is doubled the K.E. will be quadrupled

86. **(a)** K.E. $= \frac{1}{2}mv^2$ if V is tripled then K.E. $= v^2 = (3)^2$

87. **(c)** K.E. can be increased or decreased without applying any external force, as internal forces can do work e.g., explosion of a bomb.

88. **(b)**

89. **(a)**

90. **(d)** Potential energy $U = \frac{1}{2}kx^2$ *i.e.* $U \propto x^2$

This is a equation of parabola, so graph between U and x is a parabola not a straight line.

91. **(d)** P.E. of a spring either it is compressed or stretched as work is done by us on the spring.

92. **(b)** $W = Fs\cos 180° = -mgs$.

93. **(d)**

94. **(a)** Both reason and assertion are true and reason is the correct explanation of the assertion.

95. **(a)** Power $= \frac{W}{t} = \frac{K}{1/n} = nK$

96. **(d)** Work done and power developed one zero in uniform circular motion only.

97. **(d)** Total momentum and total energy both are conserved in an inelastic collision. It is the K.E. which changes.

98. **(d)** Maximum energy loss $= \frac{P^2}{2m} - \frac{P^2}{2(m+M)}$

$$\left[\because \text{K.E.} = \frac{P^2}{2m} = \frac{1}{2}mv^2\right]$$

$$= \frac{P^2}{2m}\left[\frac{M}{(m+M)}\right] = \frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}$$

Reason is a case of perfectly inelastic collision.

By comparing the equation given in Assertion with above equation, we get

$$f = \left(\frac{M}{m+M}\right) \text{ instead of } \left(\frac{m}{M+m}\right)$$

Hence Assertion is wrong and Reason is correct.

99. **(b)** **100. (b)** **101. (a)**

102. **(d)** The billiard balls in an elastic collision are in a deformed state. Their total energy is partly kinetic and partly potential. So K.E. is less than the total energy. The energy spent against friction is dissipated as heat which is not available for doing work.

CRITICALTHINKING TYPE QUESTIONS

103. **(d)** Though an equal and opposite force acts on the road but since road does not undergo any displacement, hence no work is done on the road.

104. **(c)** Motion without slipping implies pure rolling. During pure rolling work done by friction force is zero.

105. **(a)** $x = 3t - 4t^2 + t^3 \quad \frac{dx}{dt} = 3 - 8t + 3t^2$

Acceleration $= \frac{d^2x}{dt^2} = -8 + 6t$

Acceleration after 4 sec $= -8 + 6 \times 4 = 16$

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

$\therefore$ Work = Force × displacement

= Mass × acc. × disp. $= 3 \times 10^{-3} \times 16 \times 12 = 576$ mJ

106. **(d)** Given : $\vec{F} = 3\hat{i} + \hat{j}$

$$\vec{r_1} = \left(2\hat{i} + \hat{k}\right),\ \vec{r_2} = \left(4\hat{i} + 3\hat{j} - \hat{k}\right)$$

$$\vec{r} = \vec{r_2} - \vec{r_1} = \left(4\hat{i} + 3\hat{j} - \hat{k}\right) - \left(2\hat{i} + \hat{k}\right)$$

or $\vec{r} = 2\hat{i} + 3\hat{j} - 2\hat{k}$

So work done by the given force $w = \vec{f}.\vec{r}$

$$= \left(3\hat{i} + \hat{j}\right).\left(2\hat{i} + 3\hat{j} - 2\hat{k}\right) = 6 + 3 = 9\text{J}$$

107. **(c)** here, $m = 4$, $g = 4 \times 10^{-3}$ kg

$x = 4t^2 + t$

$\therefore \frac{dx}{dt} = 8t + 1 \quad \frac{d^2x}{dt^2} = 8$

Work done, $W = \int f dx = \int m \frac{d^2x}{dt^2}\left(\frac{dx}{dt}\right)dt$

$= \int_0^2 (4\times10^{-3})(8)(8t+1)\,dt$

$= 32\times10^{-3}\int_0^2 (8t+1)dt = 32\times10^{-3}\left[\frac{8t^2}{2}+t\right]_0^2$

$= 32\times10^{-3}[4(2)^2+2-0] = 576$ mJ

108. (d) The average speed of the athelete

$v = \frac{100}{10} = 10 m/s$

$\therefore$ K.E. $= \frac{1}{2}mv^2$

If mass is 40 kg then, K.E. $= \frac{1}{2}\times 40\times(10)^2 = 2000$ J

If mass is 100 kg then,

K.E. $= \frac{1}{2}\times 100\times(10)^2 = 5000$ J

109. (d) Given, $\frac{dk}{dt}$ = constant

$\Rightarrow \quad k \propto t \Rightarrow v \propto \sqrt{t}$

Also, $P = Fv = \frac{dk}{dt}$ = constant

$\Rightarrow \quad F \propto \frac{1}{v} \Rightarrow F \propto \frac{1}{\sqrt{t}}$

110. (d) Kinetic energy of a body, $K = \frac{p^2}{2m}$

As $p_1 = p_2$ (Given)

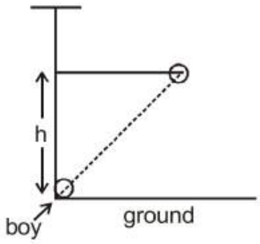
$\therefore \frac{K_1}{K_2} = \frac{m_2}{m_1} = \frac{5}{4}$

111. (d) Here, F = 100 N, d = 5 m,
frictional force $f_r = 40$ N
$\therefore F - f_r = ma$
$100 - 40 = ma$
Now kinetic energy gained is = ma × d
= 60 × 5 = 300 J

112. (b)

113. (a) This condition is applicable for simple harmonic motion. As particle moves form mean position to extreme position its potential energy increases according to expression $U = \frac{1}{2}kx^2$ and according kinetic energy decreases.

114. (a) In this case the boy has done work (see the fig.) against force of gravity acting on the weight and this work is stored in weight in the form of gravitational potential energy (work done on weight = mgh = gravitation P.E of weight).



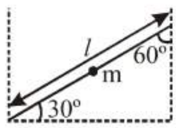
115. (d) For any uniform rod, the mass is supposed to be concentrated at its centre.

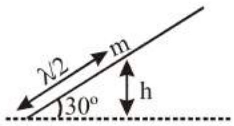
$\therefore$ height of the mass from ground is, $h = (l/2)\sin 30^\circ$

$\therefore$ Potential energy of the rod

$= m\times g\times\frac{\ell}{2}\sin 30^\circ$

$= m\times g\times\frac{\ell}{2}\times\frac{1}{2} = \frac{mg\ell}{4}$





116. (a) $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \Rightarrow mv^2 = kx^2$ or $m\times(1.5)^2 = 50\times(0.15)^2$

$\therefore m = 0.5$ kg

117. (b) Let the blow compress the spring by x before stopping.
Kinetic energy of the block = (P.E of compressed spring) + work done against function.

$\frac{1}{2}\times 2\times(4)^2 = \frac{1}{2}\times 10,000\times x^2 + (+15)\times x$

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

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

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

$= 0.055m = 5.5cm.$

118. (d) According to Hooke's law, $F_P = -k_I x_P$

$F_Q = -k_Q x_Q$ or $\frac{F_P}{F_Q} = \frac{k_P}{k_Q}\frac{x_P}{x_Q}$

$F_P = F_Q$ (Given) $\quad\therefore \frac{x_P}{x_Q} = \frac{k_Q}{k_P}$

Energy stored in a spring is $U = \frac{1}{2}kx^2$

$$\therefore \frac{U_P}{U_Q} = \frac{k_P x_P^2}{k_Q x_Q^2} = \frac{k_P}{k_Q} \times \frac{k_Q^2}{k_P^2}$$

$$\frac{U_P}{U_Q} = \frac{k_Q}{k_P} \qquad \left(\because k_Q = \frac{k_P}{2}\right)$$

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

or $U_P = \frac{U_Q}{2} = \frac{E}{2} \qquad (\because U_Q = E)$

119. (c) From Hooke's law

$F \propto x \Rightarrow F = kx.$, where k is spring constant

Since force is same in stretching for both spring so $F = k_1x_1 = k_2x_2 \Rightarrow x_1 < x_2$ because $k_1 > k_2$

so work done in case of first spring is $W_1 = \frac{1}{2}k_1x_1^2$

and work done in case of second spring is

$$W_2 = \frac{1}{2}k_2x_2^2 \text{ so } \frac{W_1}{W_2} = \frac{x_1}{x_2} \Rightarrow W_1 < W_2$$

It means that more work is done in case of second spring (work done on spring is equal to stored elastic potential energy of the spring)

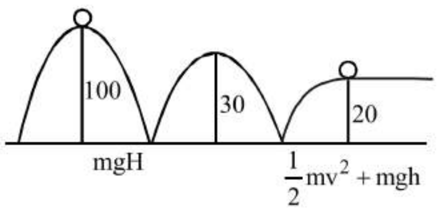
120. (a) Stored elastic potential energy of spring $= \frac{1}{2}kx^2$ where x is compression or elongation of spring from its natural length. In this position the spring can do work on the block tied to it, which is equal to $\frac{1}{2}kx^2$, so both option (a) & b are correct.

121. (d) $P.E. = \frac{1}{2}kx^2$

$\therefore$ If $x = 4x$, then $P.E = \frac{1}{2}k(16x^2) = 16\left(\frac{1}{2}kx^2\right)$

122. (b) The law of conservation of energy is valid at any instant & in all circumstances.

123. (b)



Using conservation of energy,

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

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

Alternative method :

Loss in potential energy = gain in kinetic energy

$$m \times g \times 80 = \frac{1}{2}mv^2$$

$$10 \times 80 = \frac{1}{2}v^2$$

$v^2 = 1600$ or $v = 40$ m/s

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

Potential energy = kinetic energy

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

If h_1 and h_2 are initial and final heights, then

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

Loss in velocity, $\Delta v = v_1 - v_2 = \sqrt{2gh_1} - \sqrt{2gh_2}$

$\therefore$ fractional loss in velocity

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

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

125. (b) $u = 0; v = u + aT; v = aT$

Instantaneous power $= F \times v = m.\ a.\ at = m.a^2.t$

$\therefore$ Instantaneous power $= m\frac{v^2}{T^2}t$

126. (d)

127. (a)

128. (b) Power exerted by a force is given by

$P = F.v$

When the body is just above the earth's surface, its velocity is greatest. At this instant, gravitational force is also maximum. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

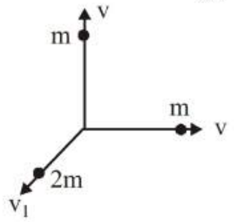
129. (b) The work is done against gravity so it is equal to the change in potential energy. $W = E_p = mgh$

For a fixed height, work is proportional to weight lifted. Since Johnny weighs twice as much as Jane he works twice as hard to get up the hill.

Power is work done per unit time. For Johnny this is W/Δt. Jane did half the work in half the time, (1/2 W)/(1/2 Δt) = W/Δt which is the same power delivered by Johnny.

130. (b) By conservation of linear momentum

$$2mv_1 = \sqrt{2}mv \Rightarrow v_1 = \frac{v}{\sqrt{2}}$$



As two masses of each of mass m move perpendicular to each other.

Total KE generated

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v_1^2$$

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

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

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

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

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

Therefore, force on the particle at time 't'

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

132. (c) $\text{Power} = \frac{\text{work done}}{\text{time}}$

Therefore power of A, $P_A = \frac{mgh}{t_A}$

and power of B, $P_B = \frac{mgh}{t_B}$

$$\therefore \quad \frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{4}{2} = 2:1$$

133. (d) $\text{Power} = \frac{\text{total work done}}{\text{time}}$

$$= \frac{\frac{1}{2}Mv^2}{t} = \frac{1}{2}(mv^2)n \left(\because \frac{M}{t} = mn\right)$$

$$= kn\left[\because K.E.\ K = \frac{1}{2}mv^2\right]$$

134. (b) Applying momentum conservation

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.1u + m(0) = 0.1(0) + m(3)$

$0.1u = 3m$

$$\frac{1}{2}0.1u^2 = \frac{1}{2}m(3)^2$$

Solving we get, $u = 3$

$$\frac{1}{2}kx^2 = \frac{1}{2}K\left(\frac{x}{2}\right)^2 + \frac{1}{2}(0.1)3^2$$

$$\Rightarrow \quad \frac{3}{4}kx^2 = 0.9$$

$$\Rightarrow \quad \frac{3}{2} \times \frac{1}{2}kx^2 = 0.9$$

$$\therefore \quad \frac{1}{2}Kx^2 = 0.6 \text{ J (total initial energy of the spring)}$$

135. (b) As we know, dU = F.dr

$$U = \int_0^r \alpha r^2 dr = \frac{\alpha r^3}{3} \qquad \text{...(i)}$$

As, $\frac{mv^2}{r} = \alpha r^2$

$m^2v^2 = m\alpha r^3$

or, $2m(KE) = \frac{1}{2}\alpha r^3 \qquad$ ...(ii)

Total energy = Potential energy + kinetic energy

Now, from eqn (i) and (ii)

Total energy = K.E. + P.E.

$$= \frac{\alpha r^3}{3} + \frac{\alpha r^3}{2} = \frac{5}{6}\alpha r^3$$

136. (c) Let E be the total energy then

$$\frac{P.E}{K.E} = \frac{mgh}{E - mgh} = \frac{2}{3} \Rightarrow E = \frac{5}{2}\text{ mgh}$$

When velocity is double then inital energy becomes $4E$.

So, $\frac{mgh}{4E - mgh} = NL = \frac{mgh}{10mgh - mgh}$

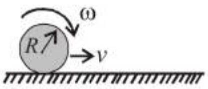
On solving we get $\frac{P.E}{K.E} = \frac{1}{9}$.

137. (a) Given, mass of the sphere, $M = 300\text{ g} = 0.3\text{ kg}$

Speed of the sphere $V = 5\text{ m s}^{-1}$

In case of rolling motion without slipping

Total energy, $K = K_{trans} + K_{rot}$



i.e., $K = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

$= \frac{1}{2}Mv^2 + \frac{1}{2}\frac{2}{5}MR^2\omega^2 \left(\because I \text{ solid sphere} = \frac{2}{5}MR^2\right)$

$= \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 \qquad (\because v = R\omega)$

$= \frac{7}{10}Mv^2 = \frac{7}{10} \times 0.3 \times 5^2 = 5.25\text{ J}$

138. (a) Let the bullet be fired with velocity ν.

For 20 cm penetration of bullet

using $v^2 - u^2 = 2as$

$\left(\frac{\nu}{2}\right)^2 - (\nu)^2 = 2a(20)$

$\Rightarrow -\frac{3}{4}\nu^2 = 40a \quad \text{or } a = -\frac{3\nu^2}{160}$ ....(i)

For latter part of penetration,

Let before it comes to rest distance travelled by the bullet be x

Again, using $v^2 - u^2 = 2as$ we get

$0 - \left(\frac{\nu}{2}\right)^2 = 2ax$

or $x = -\frac{\nu^2}{8a} = -\frac{\nu^2}{8}\left(\frac{160}{-3\nu^2}\right) = 6.66\text{ cm}$ (using eq. (i))

Therefore, the distance travelled by the bullet before it comes to rest = 6.66 cm

139. (c) Work done in stretching the rubber-band by a distance dx is

$dW = F\,dx = (ax + bx^2)dx$

Integrating both sides,

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

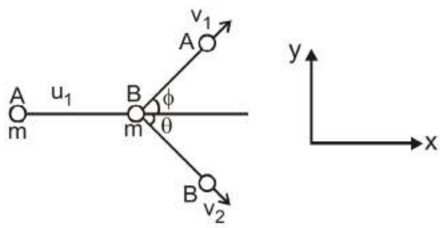
140. (a) In an elastic collision

$V_1 = \frac{(m_1 - m_2)}{m_1 + m_2}u_1$

$V_2 = \frac{2m_1u_1}{m_1 + m_2}$

$\therefore$ if $m_1 = m_2$, then $V_1 = 0$; and $V_2 = \frac{2m_1v_1}{2m_1} = u_1$

141. (c)



(a) By law of conservation of momentum

(i) along x axis

$mu_1 + 0 = mv_1\cos\phi + mv_2\cos\theta$ ....(i)

(ii) along y axis

$0 = mv_1\sin\phi - mv_2\sin\phi$. ....(ii)

(b) By law of conservation of energy

$\frac{1}{2}mu_1^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 \Rightarrow u_1^2 = v_1^2 + v_2^2$ ....(iii)

From eq (i) & (ii) we get

$u_1^2 = v_1^2 + v_2^2 + 2v_1v_2\cos(\varphi + \theta)$ ......(iv)

Now use eq.(iii) in eq.(iv), we get

$\cos(\phi + \theta) = 0 \Rightarrow \theta + \phi = 90^\circ$

ie, after collision they will move in mutually perpendicular directions.

142. (c) When two particles of mass m_1 & m_2 undergo elastic collision, then

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

$v_2 = \frac{(m_2 - m_1)u_2}{m_1 + m_2} + \frac{2m_1u_1}{m_1 + m_2}$

Where u_1 & u_2 are the initial velocity of m_1 & m_2 respectively and v_1 & v_2 are the velocity of m_1 & m_2 respectively after collision. So when $m_1 = m_2$ & $u_2 = 0$

$\Rightarrow v_2 = u_1$ & $v_1 = 0$

It means that m_1 ball has zero velocity after collision & ball m_2 moves with the velocity $v_2 = u_1$, so maximum transfer of kinetic energy.

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

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

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

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

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

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

Fractional loss

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

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

$m_2 = m\ ;\ m_1 = nm$ $\qquad 1 - \frac{K_f}{K_i} = \frac{4n}{(1+n)^2}$

Energy transfer is maximum when $K_f = 0$

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

$(n-1)^2 = 0 \qquad n = 1$ ie. $m_2 = m, \quad m_1 = m$

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

145. (c) Apply conservation of momentum,

$m_1v_1 = (m_1 + m_2)v$

$v = \frac{m_1 v_1}{(m_1 + m_2)}$

Here $v_1 = 36$ km/hr $= 10$ m/s,

$m_1 = 2$ kg, $m_2 = 3$ kg

$v = \frac{10 \times 2}{5} = 4$ m/s

K.E. (initial) $= \frac{1}{2} \times 2 \times (10)^2 = 100$ J

K.E. (Final) $= \frac{1}{2} \times (3+2) \times (4)^2 = 40$ J

Loss in K.E. $= 100 - 40 = 60$ J

Alternatively use the formula

$$-\Delta E_k = \frac{1}{2}\frac{m_1m_2}{(m_1 + m_2)}(u_1 - u_2)^2$$

146. (a) Clearly $v_1 = 2\ ms^{-1}, v_2 = 0$

$m_1 = m$ (say), $m_2 = 2m$

$v_1' = ?, v_2' = ?$

$e = \frac{v_1' - v_2'}{v_2 - v_1}$ ....(i)

By conservation of momentum,

$2m = mv_1' + 2mv_2'$ ... (ii)

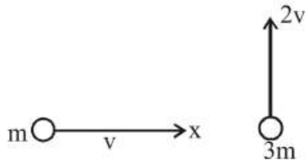
From (i), $0.5 = \frac{v_2' - v_1'}{2}$

$\therefore \quad v_2' = 1 + v_1'$

From (ii), $2 = v_1' + 2 + 2v_1'$

$\Rightarrow \quad v_1 = 0$ and $v_2 = 1\ ms^{-1}$

147. (a) As the two masses stick together after collision, hence it is inelastic collision. Therefore, only momentum is conserved.



$\therefore mv\hat{i} + 3m(2v)\hat{j} = (4m)\vec{v}$

$\vec{v} = \frac{v}{4}\hat{i} + \frac{6}{4}v\hat{j}$

$= \frac{v}{4}\hat{i} + \frac{3}{2}v\hat{j}$

148. (c) Initial kinetic energy of the system

$K.E_i = \frac{1}{2}mu^2 + \frac{1}{2}M(0)^2 = \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1J$

For collision, applying conservation of linear momentum

$m \times u = (m + M) \times v$

$\therefore \quad 0.5 \times 2 = (0.5 + 1) \times v$

$\Rightarrow \quad v = \frac{2}{3}$ m/s

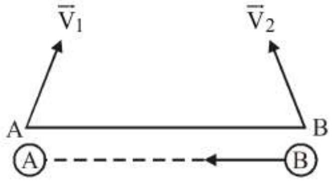
Final kinetic energy of the system is

$K.E_f = \frac{1}{2}(m+M)v^2 = \frac{1}{2}(0.5+1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3}J$

$\therefore$ Energy loss during collision $= \left(1 - \frac{1}{3}\right)J = 0.67J$

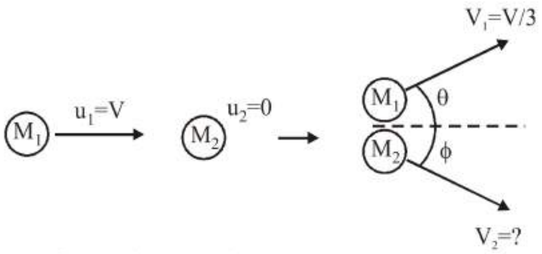
149. (d) For collision $\vec{V}_{B/A}$ should be along $\overline{B \to A}\left(\vec{r}_{A/B}\right)$

So, $\dfrac{\vec{V}_2 - \vec{V}_1}{|V_2 - V_1|} = \dfrac{\vec{r}_1 - \vec{r}_2}{|r_1 - r_2|}$



150. (d) Here, $M_1 = M_2$ and $u_2 = 0$

$u_1 = V, \quad V_1 = \dfrac{V}{3}; \qquad V_2 = ?$



From figure, along x-axis,

$M_1u_1 + M_2u_2 = M_1V_1 \cos\theta + M_2V_2 \cos\phi$ ...(*i*)

Along y-axis

$0 = M_1V_1 \sin\theta - M_2V_s \sin\phi$ ...(*ii*)

By law of conservation of kinetic energy

$\dfrac{1}{2}M_1u_1^2 + \dfrac{1}{2}M_2u_2^2 = \dfrac{1}{2}M_1V_1^2 + \dfrac{1}{2}M_2V_2^2$ ...(*iii*)

Putting $M_1 = M_2$ and $u_2 = 0$ in equation (*i*), (*ii*) and (*iii*) we get

$\theta + \phi = \dfrac{\pi}{2} = 90°$

and $u_1^2 = V_1^2 + V_2^2$

$V^2 = \left(\dfrac{V}{3}\right)^2 + V_2^2 \qquad \left[\because u_1 = V \text{ and } V_1 = \dfrac{V}{3}\right]$

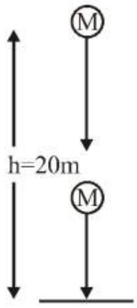
or, $V^2 - \left(\dfrac{V}{3}\right)^2 = V_2^2$

$V^2 - \dfrac{V^2}{9} = V_2^2$

or $V_2^2 = \dfrac{8}{9}V^2 \Rightarrow V_2 = \dfrac{2\sqrt{2}}{3}V$

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

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



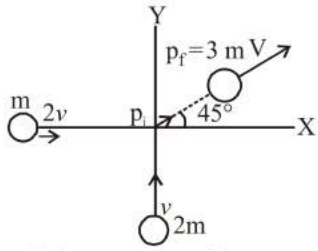
or $\dfrac{V_f}{V_i} = \dfrac{1}{\sqrt{2}}$

or, $\dfrac{\sqrt{2gh}}{\sqrt{V_0^2 + 2gh}} = \dfrac{1}{\sqrt{2}}$

or, $4gh = V_0^2 + 2gh$

$\therefore V_0 = 20 ms^{-1}$

152. (a)



Initial momentum of the system

$p_i = \sqrt{[m(2V)^2 \times m(2V)^2]}$

$= \sqrt{2}m \times 2V$

Final momentum of the system $= 3mV$

By the law of conservation of momentum

$2\sqrt{2}mv = 3mV$

$\Rightarrow \dfrac{2\sqrt{2}v}{3} = V_{combined}$

Loss in energy

$\Delta E = \dfrac{1}{2}m_1V_1^2 + \dfrac{1}{2}m_2V_2^2 - \dfrac{1}{2}(m_1 + m_2)V_{combined}^2$

$\Delta E = 3mv^2 - \dfrac{4}{3}mv^2 = \dfrac{5}{3}mv^2 = 55.55\%$

Percentage loss in energy during the collision $\simeq 56\%$