CBSE

WORK ENERGY AND POWER WS 10

Class 11 - Physics

Section A

1. Consider two 2 marbles. Marble 1 has mass 100 g and marble 2 has mass 50 g. Edward rolls marble 1 along the ground towards marble 2 in the positive x-direction. Marble 2 is initially at rest and marble 1 has a velocity of 3 m /s in the positive x-direction. After they collide elastically, both marbles are moving. What is the final velocity of each marble? **[1]**

   a) ball 1 moves to the right at 3 m /s and ball 2 moves to the left with a velocity of 2m /s

   b) ball 1 moves to the right at 5 m /s and ball 2 moves to the left with a velocity of 3m /s

   c) ball 1 moves to the right at 2 m /s and ball 2 moves to the left with a velocity of 2m /s

   d) ball 1 moves to the right with a velocity of 1m/s and ball 2 also moves to the right at 4 m/s

2. **Assertion (A):** KE is conserved at every instant of elastic collision. **[1]**
   Reason (R): No deformation of matter occurs in elastic collision.

   a) Both A and R are true and R is the correct explanation of A.

   b) Both A and R are true but R is not the correct explanation of A.

   c) A is true but R is false.

   d) A is false but R is true.

3. **Assertion (A):** The coefficient of restitution for a perfectly elastic collision is equal to one. **[1]**
   Reason (R): In a perfectly elastic collision, kinetic energy before and after the collision remains conserved.

   a) Both A and R are true and R is the correct explanation of A.

   b) Both A and R are true but R is not the correct explanation of A.

   c) A is true but R is false.

   d) A is false but R is true.

4. **Assertion:** If two bodies of equal masses undergo elastic collision in one dimension, then after the collision the bodies will exchange their velocities. **[1]**
   Reason: In elastic collision, velocity of approach is equal and opposite of velocity of separation.

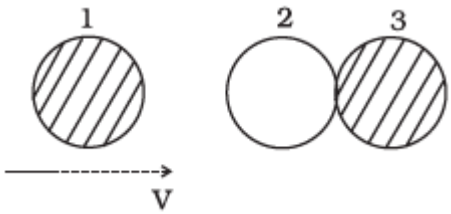
   a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

   b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

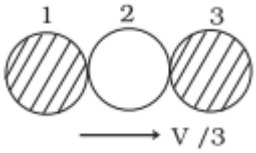
   c) Assertion is correct statement but reason is wrong statement.

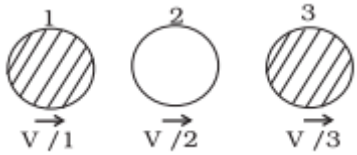
   d) Assertion is wrong statement but reason is correct statement.

5. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed V as shown in Fig. **[1]**

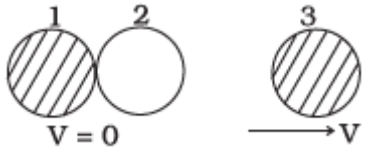


If the collision is elastic, which of the following is a possible result after collision?

a) 

b) 

c)

d) 

6. Which of the following is true? **[1]**

a) Neither momentum nor kinetic energy is conserved in inelastic collisions.

b) Momentum is conserved in all collisions, but kinetic energy is conserved only in an inelastic collision.

c) Momentum is conserved in all collisions but not kinetic energy.

d) Both momentum and kinetic energy are conserved in all collisions.

7. A bullet of mass 10 g moving horizontally with a velocity of 400 ms^{-1} strikes a wooden block of mass 2 kg which is suspended by a light inextensible string of length 5 m. As a result, the centre of gravity of the block is found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges out horizontally from the block will be **[1]**

a) 80 ms^{-1}

b) 120 ms^{-1}

c) 160 ms^{-1}

d) 100 ms^{-1}

8. Explain, throwing mud on a wall is an example of a perfectly inelastic collision. **[1]**
9. A ball is dropped from a height h on to a floor. If the coefficient of restitution is e, calculate the height to which the ball first rebounds? **[1]**
10. A spark is produced, when two stones are struck against each other. Why? **[1]**
11. Is whole of the kinetic energy lost in any perfectly inelastic collision? **[1]**
12. What is that physical quantity which is conserved both in elastic and inelastic collisions? **[1]**

Section B

13. A bolt of mass 0.3 kg falls from the ceiling of an elevator moving down with a uniform speed of 7 ms^{-1}. It hits the floor of the elevator (length of the elevator = 3 m) and does not rebound. What is the heat produced by the impact? **[2]**
14. State the law of conservation of linear momentum. Give an example for it. **[2]**
15. Two particles of masses 0.5 kg and 0.25 kg moving with velocities 4.0 ms^{-1} and -3.0 ms^{-1} collide head on in a perfectly inelastic collision. Find **[2]**

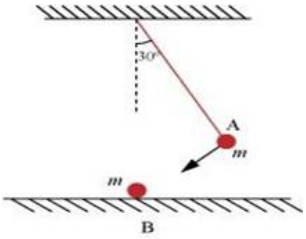
i. the velocity of the composite particle after the collision and

ii. the kinetic energy lost in the collision.

16. A 10 kg ball and 20 kg ball Approach each other with velocities 20 ms^{-1} and 10 ms^{-1} respectively. What are their velocities after a collision if the collision is perfectly elastic? **[2]**

17. A particle of mass 1 kg moving with a velocity $v_1 = (3\hat{i} - 2\hat{j})$ m/s experiences a perfectly inelastic collision with another particle of mass 2 kg having velocity $v_2 = (4\hat{j} - 6\hat{k})$ m/s. Find the final velocity and speed of the particles. **[2]**

18. The bob A of a pendulum released from 30° to the vertical hits another bob B of the same mass at rest on a table as shown in figure. How high does the bob A rise after the collision? Neglect the size of the bobs and assume the collision to be elastic. **[2]**



19. Underline the correct alternative : **[2]**
    a. When a conservative force does positive work on a body, the potential energy of the body increases/decreases/remains unaltered.
    b. Work done by a body against friction always results in a loss of its kinetic/potential energy.
    c. The rate of change of total momentum of a many-particle system is proportional to the external force/sum of the internal forces on the system.
    d. In an inelastic collision of two bodies, the quantities which do not change after the collision are the total kinetic energy/total linear momentum/total energy of the system of two bodies.

20. Explain how fast-moving neutrons can be quickly slowed down by passing through water or heavy water. **[2]**

21. Two ball bearings of mass m each, moving in opposite directions with equal speed collide head on with each other. Predict the outcome of the collision, assuming it to be perfectly elastic. **[2]**

22. A neutron moving with a speed of 10^6 ms^{-1} suffers a head-on collision with a nucleus of mass number 80. What is the fraction of energy retained by the nucleus? **[2]**

23. Two ball bearings of mass m each, moving in opposite directions with equal speed v collide head-on with each other. Predict the outcome of the collision, assuming it to be perfectly elastic. **[2]**

24. A vehicle of mass 30 quintals moving with a speed of 18 km h^{-1} collides with another vehicle of mass 90 quintals moving with a speed of 14.4 km h^{-1} in the opposite direction. What will be the velocity of each after the collision? **[2]**

25. Why a metal ball rebounds better than a rubber ball? **[2]**

26. A ball is dropped on a floor from a height of 2m. After the collision, it rises up to a height of 1.5 m. Assuming that 40% of mechanical energy lost goes to thermal energy into the ball. Calculate the rise in temperature of the ball in the collision. The specific heat capacity of the ball is 800J/k. Take g = 10 m/s^2. **[2]**

27. A large mass M moving with a velocity v collides head-on with a very small mass m at rest. If the collision is elastic, obtain an expression for the energy lost by the large mass M (Take M + m ≈ M). **[2]**

28. A particle of mass 1 g moving with a velocity $\overrightarrow{v_1} = 3\hat{i} - 2\hat{j}$ experiences a perfectly elastic collision with another particle of mass 2 g and velocity $\overrightarrow{v_2} = 4\hat{j} - 6\hat{k}$. Find the velocity of the particle formed (both $\vec{v}$ and v). ($\overrightarrow{v_1}$ and $\overrightarrow{v_2}$ are given in SI units). **[2]**

29. A ball is dropped from the height h_1 and if it rebounds to a height h_2. Find the value of the coefficient of **[2]**

restitution?

30. Two bodies of masses 5 kg and 3 kg moving in the same direction along the same straight line with velocities 5 ms^{-1} and 3 ms^{-1} respectively suffer a one-dimensional elastic collision. Find their velocities after the collision. **[2]**

31. Show that the coefficient of restitution for one-dimensional elastic collision is equal to one. **[2]**

32. Show that in the case of one-dimensional elastic collision of two bodies, the relative velocity of separation after the collision is equal to the relative velocity of approach before the collision. **[2]**

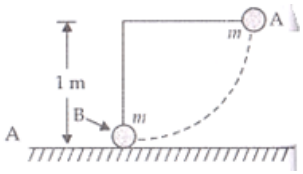
Section C

33. **State True or False:** **[3]**
    (a) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system. **[1]**
    (b) In an elastic collision of two billiard balls, the total kinetic energy is not conserved during the short time of collision of balls i.e., when they are in contact. **[1]**
    (c) The relative velocity of two particles in a head-on collision remains unchanged both in magnitude and direction. **[1]**

34. **Fill in the blanks:** **[3]**
    (a) For a perfectly inelastic collision, the relative velocity of separations is _____. **[1]**
    (b) _____ collision is a collision during which there is no loss of kinetic energy. **[1]**
    (c) When the two colliding bodies together and move as a single body with a common velocity after the collision, then the collision is _____. **[1]**

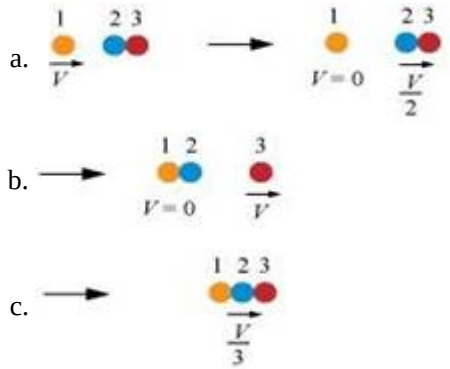
35. An engine is attached to a wagon through a shock absorber of length 1.5 m. The system with a total mass of 50,000 kg is moving with a speed of 36 km/h when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, calculate the spring constant. **[3]**

36. The bob A of a pendulum released from horizontal to the vertical hits another bob B of the same mass at rest on a table as shown in figure. **[3]**
    If the length of the pendulum is 1m, calculate



    i. the height to which bob A will rise after collision.
    ii. the speed with which bob B starts moving. Neglect the size of the bobs and assume the collision to be elastic.

37. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed V. If the collision is elastic, which of the following figure is a possible result after collision? **[3]**



38. A ball moving with a speed of 9 m/s strikes an identical ball at rest, such that after collision, the direction of each ball makes an angle of 30^0 with the original line of motion. Find the speed of the two balls after collision. **[3]**

39. A ball of mass *m*, moving with a speed $2v_0$, collides inelastically (e > 0) with an identical ball at rest. Show that **[3]**

    i. For head-on collision, both the balls move forward.

    ii. For a general collision, the angle between the two velocities of scattered balls is less than 90°.

40. A ball moving with a speed of 9 ms^{-1} strikes an identical ball such that after the collision toe direction of each ball makes an angle 30^o with the original, line of motion. Find the speeds of the two balls after the collision. Is the kinetic energy conserved in the collision process? **[3]**

41. A particle of mass m moving with an initial velocity u collides inelastically with a particle of mass M initially at rest. If the collision is completely inelastic then find expressions for **[3]**

    i. final velocity of combined entity, and

    ii. loss in kinetic energy during collision.

42. A sphere of mass m moving with a velocity u hits another stationary sphere of the same mass. If e is the coefficient of restitution, what is the ratio of the velocities of two spheres after the collision? **[3]**

43. Prove that in an elastic collision in one dimension the relative velocity of approach before impact is equal to the relative velocity of separation after impact. **[3]**

44. An object of mass 0.4 kg moving with velocity of 4 m/s collides with another object of mass 0.6 kg moving in same direction with a velocity of 2 m/s . If the collision is perfectly inelastic, what is the loss of KE due to impact? **[3]**

45. A railway carriage of mass 9000 kg moving with a speed of 36 kmh^{-1} collides with a stationary carriage of the same mass. After the collision, the carriages get coupled and move together. What is their common speed after collision? What type of collision is this? **[3]**

46. Prove that when a particle suffers an oblique elastic collision with another particle of equal mass and initially at rest, the two particles would move in mutually perpendicular directions after collisions. **[3]**

47. Answer carefully, with reasons: **[3]**

    a. In an elastic collision of two billiard balls, is the total kinetic energy conserved during the short time of collision of the balls (i.e. when they are in contact)?

    b. Is the total linear momentum conserved during the short time of an elastic collision of two balls?

    c. What are the answers to (a) and (b) for an inelastic collision?

    d. If the potential energy of two billiard balls depends only on the separation distance between their centres, is the collision elastic or inelastic?

    (Note, we are talking here of potential energy corresponding to the force during collision, not gravitational potential energy)

48. A body of mass m moving with speed v collides elastically head-on with another body of mass m initially at rest. Show that the moving body will come to a stop as a result of this collision. **[3]**

49. A particle of mass m moving with an initial velocity u collides inelastically with a particle of mass M initially at rest. If the collision is completely inelastic, then find expressions for **[3]**

    i. final velocity of combined entity and

    ii. loss in kinetic energy during collision.

50. A man carrying mass M = 125 kg makes a flying tackle at Vj = 4 m/s on a stationary quarterback of mass m = 85 kg and his helmet makes solid contact with quarterback's femur. **[3]**

i. What is the final speed of two athletes immediately after contact and also determine the average force exerted on the quarterback's femur, when the last collision occur at 0.100 s?

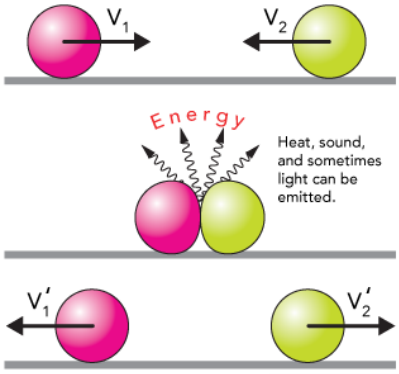
ii. If the area of cross-section of quarterback's femur is 5×10^4 m^2, then estimate the shear stress exerted on the femur in the collision.

51. A trolley of mass 200 kg moves with a uniform speed of 36 km/h on a frictionless track. A child of mass 20 kg runs on the trolley from one end to the other (10 m away) with a speed of 4 ms^{-1} relative to the trolley in a direction opposite to its motion, and jumps out of the trolley. What is the final speed of the trolley? How much has the trolley moved from the time the child begins to run? **[3]**

Section D

Question No. 52 to 55 are based on the given text. Read the text carefully and answer the questions: **[4]**

An **elastic collision** is a **collision** in which there is no net loss in kinetic energy in the system as a result of the **collision**. Both momentum and kinetic energy are conserved quantities in **elastic collisions**.



52. Describe a motion in which the momentum changes but K.E does not?

53. Two balls after collision, stick to each other, What type of collision is it?

54. What happens to the momentum of two objects moving with the same speed but in opposite directions upon collision?

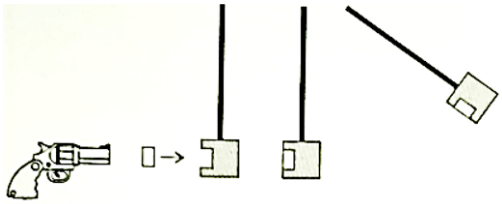
55. In elastic collision, What is the ratio of relative speed of approach and separation.

Section E

Question No. 56 to 60 are based on the given text. Read the text carefully and answer the questions: **[5]**

The ballistic pendulum was invented in 1742 by English mathematician Benjamin Robins.

A Ballistic Pendulum is a device for measuring a bullet's momentum and speed by employing perfectly inelastic collision.



A large wooden block suspended by two cords serves as the pendulum bob. When a bullet is fired into the bob, it gets embedded in the bob and its momentum is transferred to the bob.

The bullet's momentum and velocity can be determined from the amplitude of the pendulum swing. The velocity of the bullet, in turn, can be derived from its calculated momentum.

After collision, if the pendulum reaches a height h, then from principle of conservation of mechanical energy

$\frac{1}{2}(m + M)v_p^2$ = (m + M)gh

where, m= mass of bullet, M = mass of the bob v_P = velocity of the bob-bullet combination

$\therefore v_p = \sqrt{2gh}$

Now, Momentum before collision = Momentum after collision

$mv_B = (m + M)v_p$

where, v_B = velocity of bullet

$v_B = \frac{m+M}{m}\sqrt{2gh}$

the ballistic pendulum used to be a common tool for the determination of the muzzle velocity of bullets as a measure of the performance of firearms and ammunition (Nowadays, the ballistics pendulum has been replaced by the ballistic chronograph, an electronic device).

56. In ballistic pendulum the collision is

a) Perfectly inelastic
b) Partly elastic, partly inelastic
c) Elastic
d) Inelastic

57. Which two principles of Physics are applied to find the velocity of the bullet?

a) conservation of mass and conservation of momentum
b) conservation of mechanical energy, conservation of momentum and conservation of mass
c) conservation of mechanical energy and conservation of momentum
d) conservation of mechanical energy and conservation of mass

58. The ballistic pendulum was invented by a

a) Chemist
b) Warrior
c) Mathematician
d) Physicist

59. Ballistic pendulum has been replaced by

a) Gyrograph
b) Seismograph
c) Tachograph
d) Chronograph

60. A ballistic pendulum of 1 kg is fired with a bullet of mass 1 g. If the pendulum rises 2 cm, find the velocity of the bullet.

a) 6330 m/s
b) 0.633 m/s
c) 12.65 m/s
d) 633 m/s

61. A rocket accelerates straight up by ejecting gas downwards. In a small time interval Δ*t*, it ejects a gas of mass Δm at a relative speed *u*. Calculate KE of the entire system at $(t + \Delta t)$ and *t* and show that the device that ejects gas does work $= \frac{1}{2}\Delta m u^2$ in this time interval (neglect gravity). **[5]**

62. i. Distinguish between elastic and inelastic collisions. **[5]**
ii. Prove that in a two-dimensional elastic collision of a moving ball with another stationary identical ball, the two balls move perpendicular to each other after collision.

63. Define elastic and inelastic collision. A lighter body collides with a much more massive body at rest. Prove that the direction of the lighter body is reversed and the massive body remains at rest. **[5]**

64. Define elastic collision and discuss it for two bodies in one dimension. Calculate the velocities of bodies after collision. Discuss special cases also. **[5]**

65. A ball moving on a horizontal frictionless plane hits an identical ball at rest with a velocity of 0.5 ms^{-1}. If the collision is elastic, calculate the speed imparted to the target ball if the speed of the projectile after the collision is 30 cm s^{-1}. Show that the two balls will move at right angles to each other after the collision. **[5]**

66. Define elastic collision. Two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 undergo one-dimensional elastic collision. Determine their velocities after the collision. **[5]**

67. Prove that bodies of identical masses exchange their velocities after the head-on elastic collision. **[5]**

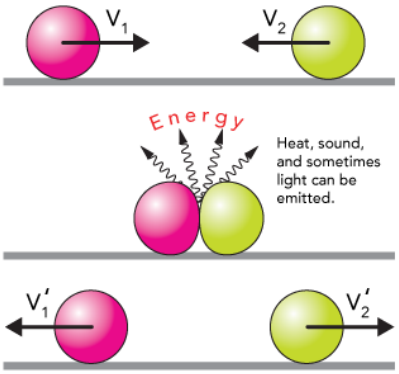
68. Show that when a moving body collides with the stationary body of mass m or $\frac{1}{m}$ times its mass, then the moving body transfers $\frac{4m}{(1+m)^2}$ part of its kinetic energy to the stationary body. **[5]**

69. Show that there is a loss of kinetic energy during a one-dimensional inelastic collision. How will you account for this loss of energy? **[5]**

70. Define the terms Elastic collision and Inelastic collision. What is the difference between an inelastic collision and a completely inelastic collision? **[5]**

71. **Read the case study given below and answer any four subparts:** **[5]**

An **elastic collision** is a **collision** in which there is no net loss in kinetic energy in the system as a result of the **collision**. Both momentum and kinetic energy are conserved quantities in **elastic collisions**.



i. In which motion, momentum changes but K.E does not?

a. circular motion
b. parabolic motion
c. straight line motion
d. none of these

ii. coefficient of restitution for elastic collision is:

a. 0
b. 1
c. -1
d. infinite

iii. Two balls at the same temperature collide. What is conserved?

a. momentum
b. velocity
c. kinetic energy
d. none of these

iv. Momentum of two objects moving with the same speed but in opposite direction upon collision is

a. increased
b. decreased
c. zero
d. none of these

v. In elastic collision, the relative speed of approach and separation is:

a. equal

b. unequal

c. zero

d. infinite