Higher Grade Physics

OUR DYNAMIC UNIVERSE

Collisions, Explosions & Impulse

Collisions

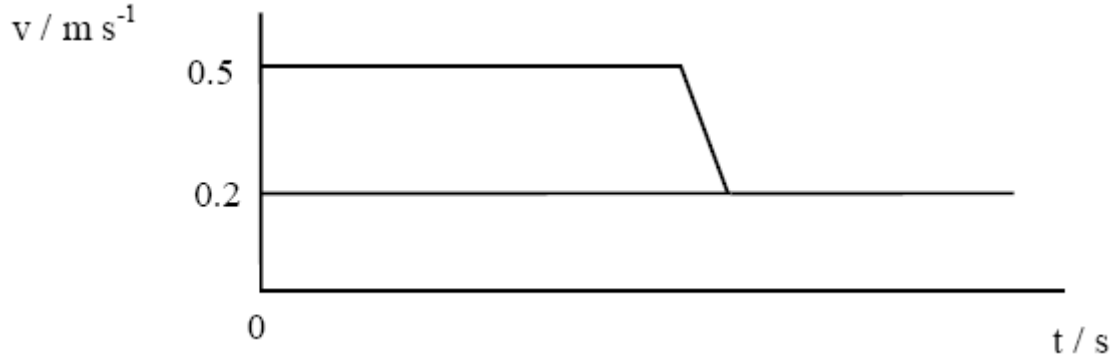
1. A trolley of mass 4.0 kg travelling at 3.0 ms^{-1} collides with a stationary 2.0 kg trolley.
   (a) If the two trolleys stick together, what is the velocity of the combination after the collision ?
   (b) How much kinetic energy is lost in the collision?

2. A 500 g vehicle collides with a stationary 200 g vehicle. If the two vehicles move off together at 2.0 ms^{-1} what was the velocity of the 500 g vehicle?

3. An object of mass 2.4 kg travelling at 6.0 ms^{-1} collides with a stationary object. The two objects stick together and move off at 4.5 ms^{-1}. What was the mass of the stationary object?

4. A car travelling at 12 ms^{-1} collides with and sticks to a stationary van of mass 3000 kg.
   The wreckage initially has a speed of 3.0 ms^{-1}. What is the mass of the car?

5. A trolley of mass 2 kg is moving at constant speed when it collides and sticks to a second trolley which was originally stationary. The graph shows how the speed of the 2 kg trolley varies with time.



   Determine the mass of the second trolley.

6. In an experiment an air gun was used to fire a 0.5 g pellet at a stationary vehicle on a linear air track. The pellet embedded itself in plasticine attached to the vehicle. The resultant velocity of the air track vehicle was measured using a light gate and found to be 25 cms^{-1}.
   If the mass of the air track vehicle, including the plasticine, was 400 g, what was the velocity of the pellet?

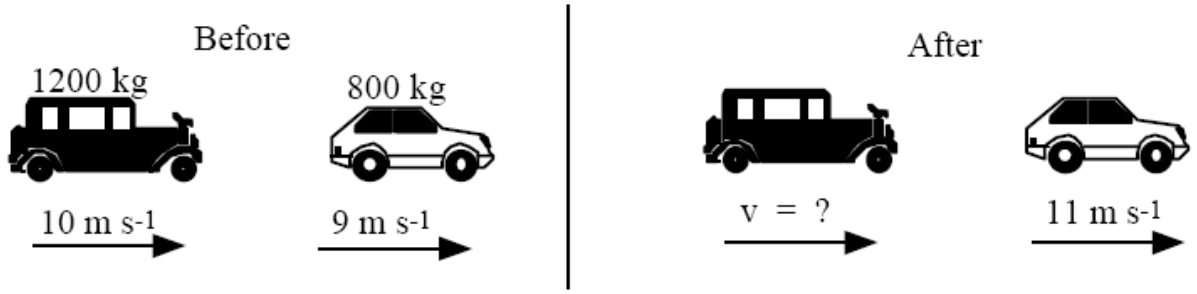
7. In space two spaceships make a docking manoeuvre (joining together). One spaceship has a mass of 1500 kg and is moving at 8 ms^{-1}. The second spaceship has a mass of 2000 kg and is approaching from behind at 9 ms^{-1}. Determine their common velocity after docking.

8. In an air track experiment a 400 g vehicle moving at 40 cms^{-1} catches up with a second vehicle, mass 200g, travelling at 25 cms^{-1} in the same direction.
   (a) If they stick together, what is the resulting velocity?
   (b) What is the loss of kinetic energy?

9. In a similar experiment the 400 g vehicle, travelling at 50 cms^{-1} meets and sticks to a 600 g vehicle travelling at 20 cms^{-1} in the opposite direction. What is the velocity of the combination?

10. On the same air track a vehicle, mass 200g, velocity 40 cms^{-1} collides and sticks to a 300 g vehicle moving at 30 cms^{-1} in the opposite direction. What is the resulting velocity?

11. One vehicle approaches another from behind as shown.



The vehicle at the rear is moving faster than the one in front and they collide which causes the vehicle in front to be 'nudged' forward with an increased speed. Determine the speed of the rear vehicle after the collision.

12. A 12 kg trolley travelling at 4.0 ms^{-1} collides with a stationary 4.0 kg trolley which then moves off at 6.0 ms^{-1}.
    (a) What is the resulting velocity of the 12 kg trolley?
    (b) Is the collision elastic?

13. A 4.0 kg object moving at 6.0 ms^{-1} strikes a stationary 2.0 kg object. The 4.0 kg object has a velocity of 3.0 ms^{-1} in the same direction after the collision.
    (a) What is the velocity of the 2.0 kg object?
    (b) Is this an elastic collision?

14. A 1200 kg car runs into a stationary 1000 kg car. Immediately after the collision the 1200 kg car is moving at 6.5 ms^{-1} and the 1000 kg car at 16 ms^{-1} both in the same direction.
    What is the initial velocity of the 1200 kg car?

15. Patrick on a sailboard travelling at 12 ms^{-1} runs into a stationary sailboard of mass 25 kg. The sailboard's speed is reduced to 8.0 ms^{-1} and the 25 kg board moves off at 16 ms^{-1}.
    What is the total mass of Patrick, who is not injured, and his sailboard?

Explosions

16. Two air track vehicles, of mass 400 g and 600 g respectively, are fitted with repelling magnets and held in contact. When released, the 400g vehicle has a velocity of 48 cms^{-1}.
    What is the velocity of the 600g vehicle?

17. The experiment of question 16 is repeated with different vehicles. After release one vehicle, mass 500 g, is travelling at 24 cms^{-1} and the other has a velocity of 15 cms^{-1} in the opposite direction.
    What is the mass of the other vehicle?

18. An artillery shell travelling at 200 ms^{-1} explodes into two parts. Immediately after the explosion one fragment, mass 5.0 kg, is travelling at 350 ms^{-1} in the same direction. If the mass of the second fragment is 15 kg, what is its velocity after the explosion?

19. A space probe, total mass 24 000 kg, sheds its booster rocket, mass 20 000 kg, by means of a small explosion. After the explosion the remaining 4 000 kg capsule travels at 6 000 ms^{-1} and the booster rocket at 1 200 ms^{-1} in the same direction.
    What was the velocity before the explosion?

20. A 50 kg boy riding on a trolley travelling at 12.0 ms^{-1} jumps off the back of the trolley. The boy's speed on leaving the trolley is 2.0 ms^{-1} in the opposite direction and the trolley's speed increases to 15.5 ms^{-1}.
    What is the mass of the trolley?

Impulse

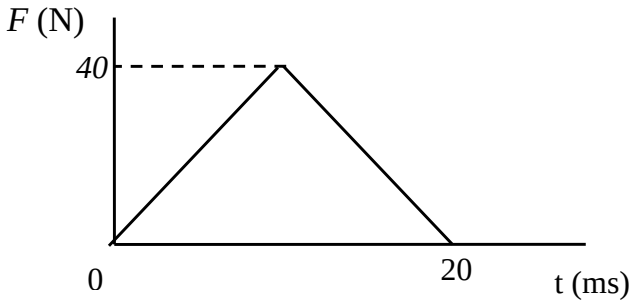
21. A force of 200N acts on a 50 kg trolley for 20 ms.
    (a) What is the impulse of the force?
    (b) What is the change of momentum of the trolley?
    (c) If the trolley is initially at rest, what is the resulting velocity?

22. A football player kicks a stationary 500 g football, giving it a velocity of 25 ms^{-1}. If the foot and ball are in contact for 20 ms, what is the average force exerted?

23. A cue exerts an average force of 7.00 N on a stationary snooker ball of mass 200 g. The impact of the cue on the ball lasts for 45.0 ms.
    What is the speed of the ball as it leaves the cue?

24. A snooker cue strikes a stationary ball of mass 7.5 g, giving it a velocity of 90 cms^{-1}. If the cue exerts a force of 4.5 N, what is the time of contact between cue and ball?

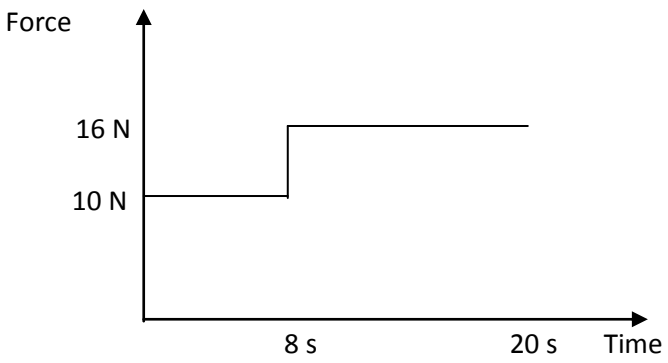
25. The graph below shows how the force exerted by a hockey stick on a stationary ball varies with time.



    The mass of the ball is 150 g. Determine the speed of the ball as it leaves the stick.

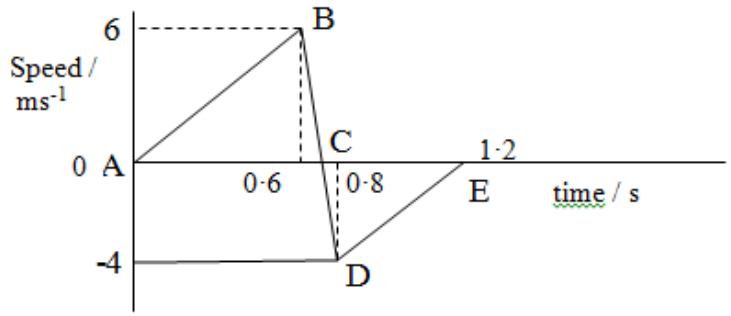
26. A tennis player strikes a ball, mass 100 g, moving towards him at a speed of 40 ms^{-1} and returns it to his opponent at 25 ms^{-1}.
    (a) What is the change in momentum of the ball?
    (b) What is the impulse of the force exerted on the ball?
    (c) If the ball is in contact with the racket for 130 ms, what is the average force exerted by the racket?

27. The graph opposite shows the variation of the force acting on an object of mass 12kg over a period of 20 s. If the object starts from rest, what is its final velocity?



28. A rubber ball of mass 40 g is dropped from a height of 0.8 m onto the pavement. It rebounds to a maximum height of 0.45 m. The average force of contact between the pavement and the ball is 2.8 N.
    (a) Calculate the velocity of the ball just before it hits the ground and the velocity just after hitting the ground.
    (b) Calculate the time of contact between the ball and pavement.

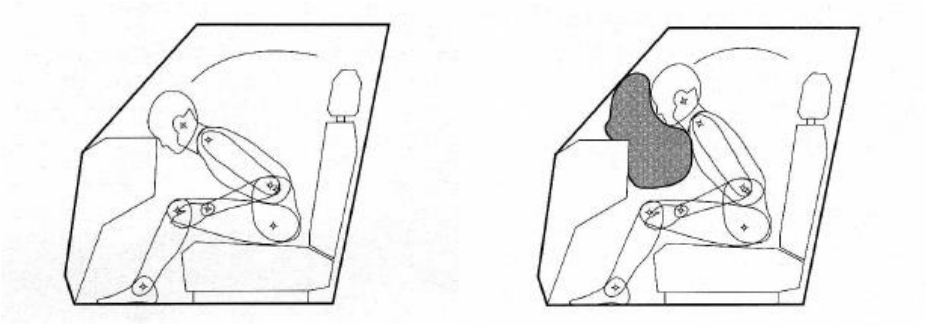
29. A ball of mass 400 g travels from rest and hits the ground. The velocity-time graph represents the motion of the ball for the first 1.2 s after it starts to fall.



    (a) Describe the motion of the ball during sections AB, BC, CD and DE on the graph.
    (b) What is the time of contact of the ball with the ground?
    (c) Calculate the average unbalanced force of the ground on the ball.
    (d) How much energy is lost due to contact with the ground?

30. A 2 kg trolley travelling at 6 ms^{-1} collides with a stationary 1 kg trolley.
    (a) If they remain connected, calculate:
        (i) their combined velocity
        (ii) the momentum gained by the 1 kg trolley
        (iii) the momentum lost by the 2 kg trolley.
    (b) If the collision time is 0.5 s, find the force acting on each trolley.

31. During a safety test, a dummy in a car is used to demonstrate the effects of a collision.
    During the collision, the head of the dummy moves towards the dashboard and comes to rest.



    Explain why there is less risk of damage to the head of the crash test dummy when an air bag is used.