Newton's Laws of Motion, Momentum and Impulse Supplementary Questions

Study Guide 18

Part 1 - Momentum and Newton's Second Law of Motion

1. What is the magnitude of the momentum of an alpha-particle of mass 6.6×10^{-26} kg travelling at a speed of 2.0×10^{7} m/s?

2. What is the magnitude of the momentum of an electron of mass 9.11×10^{-31} kg travelling at a speed of 7.5×10^{6} m/s?

3. A car being used for crash tests slams into a solid concrete block at 20 m/s. For a car of mass 1400 kg the average stopping force is 480 kN. Calculate how long it takes for the car to come to rest in this crash.

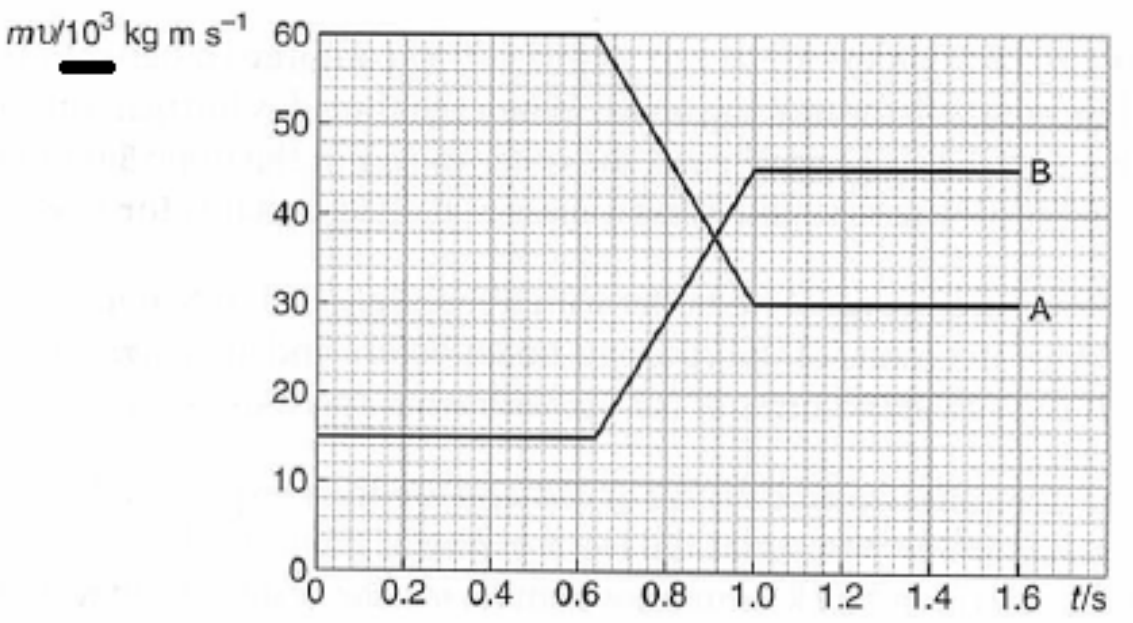
4. An insect of mass 3.4 mg, flying at a speed of 0.10 m/s, encounters a spider's web which brings it to rest in 2.2 ms. Calculate the force exerted by the web on the insect.

5. A golfer hits a ball of mass 50 g at a speed of 40 m/s. The golf club is in contact with the ball for 3.0 ms. Determine the average force exerted by the club on the ball.

6. When a particular rocket is taking off, the exhaust gases are expelled at a rate of 900 kg/s and a speed of 40 km/s. Calculate the thrust on the rocket.

7. 75 kg of air passes through an aircraft jet engine every second. The exhaust speed of the air is 550 m/s greater than the intake speed. Calculate:
   i) the change in momentum of the air in one second;
   ii) the force exerted on the air to change its momentum in this way;
   iii) the thrust produced by the aircraft's four engines.

8. The graph shows how the momentum of two colliding railway carriages varies with time. Truck A has a mass of 20 tonnes and truck B has a mass of 30 tonnes.



i) Compute the change in momentum of truck A;

ii) Compute the change in momentum of truck B;

iii) Determine the initial velocity of truck A;

iv) Determine the final velocity of truck B;

v) Calculate the average retarding force acting on truck A due to truck B.

9*. Gas molecules, each of mass 4.8×10^{-26} kg, collide with a flat surface. The average speed of the molecules perpendicular to the surface is 500 m/s both before and after they collide with it. Determine:

i) the change in momentum of a molecule as a result of one collision;

ii) how many molecules collide with 1 mm^2 each second to produce a force of 0.1 N;

iii) the pressure produced by this bombardment.

Part 2 - Impulse

1. A stationary pool ball of mass 0.23 kg is struck by a cue which exerts an average horizontal force of 75 N on it. The cue is in contact with the ball for 7.5 ms. Determine the speed of the ball after the impact.

2. A stationary golf ball is hit with a club which exerts an average force of 75 N over a time of 0.03 seconds. Calculate:
   i) the change in momentum of the golf ball;
   ii) the velocity acquired by the ball if it has a mass of 0.025 kg.

3. A squash ball of mass 0.028 kg is hit with a racket and acquires a velocity of 10 m/s. Its initial velocity is zero. If the time of contact with the racket head is 0.035 seconds, calculate the average force exerted on the ball.

4. A machine gun fires bullets at a rate of 300 per minute. The bullets have a mass of 18 g and a speed of 550 m/s upon leaving the gun. Calculate the average force exerted by the gun on the person holding it.

5. A tennis player can serve the ball, of mass 60 g, at an initial horizontal speed of 52 m/s. The ball remains in contact with the racket for 0.065 seconds. Compute the average force exerted on the ball during the serve.

6. In the proceeding rally, the tennis player's opponent from the previous question receives the ball horizontally at a speed of 20 m/s. The opponent hits the ball straight back, that is horizontally, so that it leaves his racket with a speed of 25 m/s. Determine:
   i) the change in momentum of the ball;
   ii) the impulse of the force which the racket exerts on the ball;
   iii) the average force exerted on the ball if the ball is in contact with the racket for 0.09 seconds.

Answers - Newton's Laws of Motion, Momentum and Impulse Supplementary Questions

Part 1

1. 1.32×10^{-18} kg m/s
2. 6.83×10^{-24} kg m/s
3. 0.0583 seconds
4. 1.55×10^{-4} N
5. 667 N
6. 3.6×10^{7} N
7. i) 41,250 kg m/s ii) 41,250 N iii) 1.65×10^{5} N
8. i) -30×10^{3} kg m/s ii) 30×10^{3} kg m/s iii) 3 m/s
   iv) 1.5 m/s v) 8.33×10^{4} N
9*. i) 4.8×10^{-23} kg m/s ii) 2.08×10^{21} iii) 1.00×10^{5} Pa

Part 2

1. 2.45 m/s
2. i) 2.25 kg m/s ii) 90 m/s
3. 8 N
4. 49.5 N
5. 48 N
6. i) 2.7 kg m/s ii) 2.7 kg m/s iii) 30 N