JURONG PIONEER JUNIOR COLLEGE
9478 H2 PHYSICS

COLLISIONS TUTORIAL

Self-Check Questions

S1 What is meant by the *impulse* of a force? How is it obtained from the force-time graph?

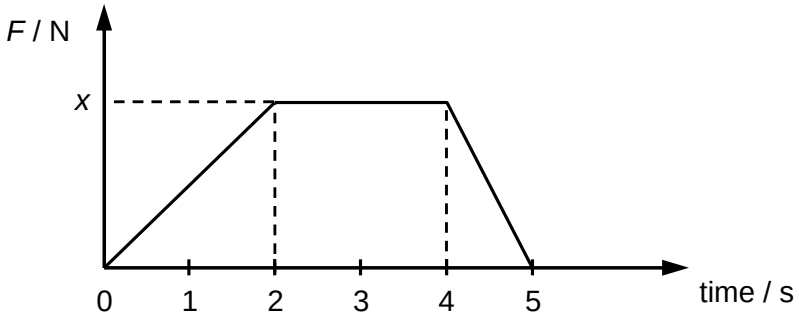
S2 State the Principle of Conservation of Momentum.

S3 Use Newton's Laws to derive the Principle of Conservation of Momentum.

S4 Explain what is meant by *elastic*, *inelastic* and *completely inelastic collisions*.

Self-Practice Questions

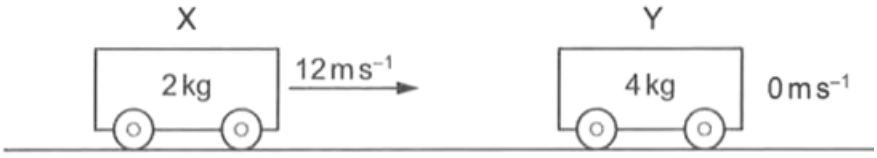
P1 When a varying force F is applied to a body of mass 10 kg, the gain in momentum in 5 s is 35 kg m s^{-1}.



Determine the value of x.

P2 The diagram shows two trolleys, X and Y, of mass 2 kg and 4 kg respectively.

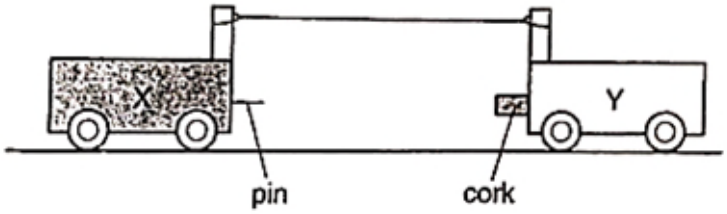
Trolley X is moving with a velocity of 12 m s^{-1} towards the stationary trolley Y.



What is the total momentum of the two trolleys after the collision?

A 2 kg m s^{-1} **B** 6 kg m s^{-1} **C** 24 kg m s^{-1} **D** 72 kg m s^{-1}

P3 The diagram shows two trolleys X and Y held stationary and connected by an extended elastic cord. The mass of X is twice that of Y.

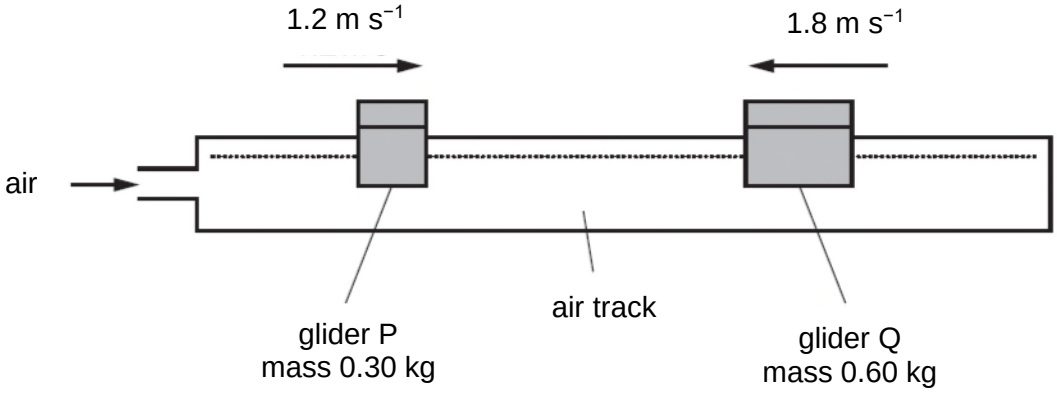


The trolleys are released at the same instant. They move towards each other and stick together on impact. Just before the collision, the speed of X is 20 cm s^{-1}.

What is the speed of Y after the collision?

A zero **B** 5 cm s^{-1} **C** 7 cm s^{-1} **D** 10 cm s^{-1}

P4 Two gliders are travelling towards each other on a horizontal air track. Glider P has mass 0.30 kg and is moving with a constant speed of 1.2 m s^{-1}. Glider Q has mass 0.60 kg and is moving with a constant speed of 1.8 m s^{-1}.



The gliders have an elastic collision.

What are the speeds of the two gliders after the collision?

	speed of P / m s^{-1}	speed of Q / m s^{-1}
A	1.2	0.6
B	2.0	1.4
C	2.8	0.2
D	3.6	0.6

Answer Key

P1 10 N P2 C P3 A P4 C

Discussion Questions

1 A particle of mass m travelling with velocity u collides elastically and head-on with a stationary particle of mass M.

Derive an expression for the velocity of the particle of mass M, v_M, after the collision.

The quantity $v = v_M - v_m$ is calculated. The experiment is repeated for different values of u. Sketch the graph that shows the variation of v with u.

2 [2004 P3 Q2]

(a) In a collision between two bodies A and B, the force that A exerts on B varies with time in the way shown in Fig. 2.1.

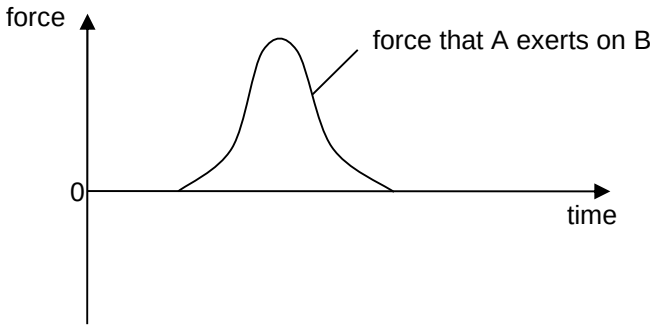


Fig. 2.1

(i) Copy Fig. 2.1 and show on your sketch a graph of the force that B exerts on A.

(ii) Explain your answer to **(i)**.

(iii) Explain how your answer to **(i)** is consistent with the principle of conservation of momentum.

(b) In a collision, when a truck of mass 12 000 kg runs into the back of car of mass 1200 kg, a constant force of 72 000 N acts for 0.25 s.

Calculate the change in velocity of the car and the truck.

(c) Suggest one way in which the conditions in **(b)** are unrealistic.

(d) Discuss how seat belts and air bags in a car ensure greater safety.

(e) In order to reduce the number of road traffic accidents, many countries conduct research into improving road safety. One area of research concerns braking.

State **three** factors that affect braking which might be considered by researchers.

3 [2007 P3 Q1]

A positively charged nucleus A moves towards another positively charged nucleus B as shown in Fig. 3.1.

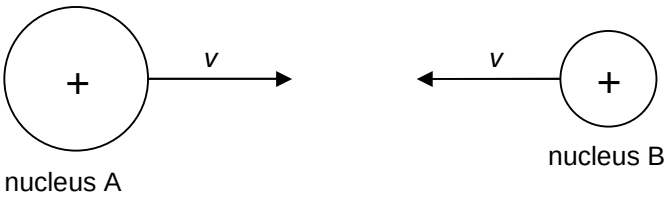


Fig. 3.1

The nuclei initially have the same speed v. The mass of nucleus A is $3m$ and that of nucleus B is $2m$. In this case, the electrostatic forces acting on the nuclei are so much larger than gravitational forces that the latter can be safely ignored.

(a) (i) State why the two nuclei will repel one another.

(ii) Explain why it is not possible for the nuclei to stop at the same instant

(b) At one instant during the interaction between the nuclei, they are both travelling in the same direction with the same speed.

Calculate this speed, in terms of v.

(c) Fig. 3.2 is a velocity-time sketch graph showing how the velocity of each nucleus varies. The interaction between the nuclei is elastic.

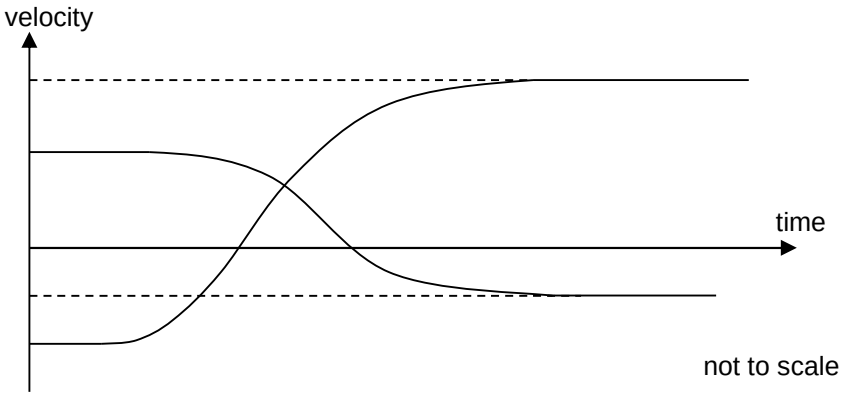


Fig. 3.2

(i) Label the graph to show

1. which curve is for nucleus A,

2. the times, t_A and t_B, at which each nucleus stops,

3. the time t_C at which they are at their distance of closest approach.

(ii) Determine the final speed of each nucleus in terms of v.

4 [2000 P3 Q1(part)]

(a) In a gas a hydrogen molecule, mass 2.00*u* and velocity 1.88 × 10^3 m s^{-1}, collides elastically and head-on with an oxygen molecule, mass 32.0*u* and velocity 405 m s^{-1}, as shown in Fig. 4.1.

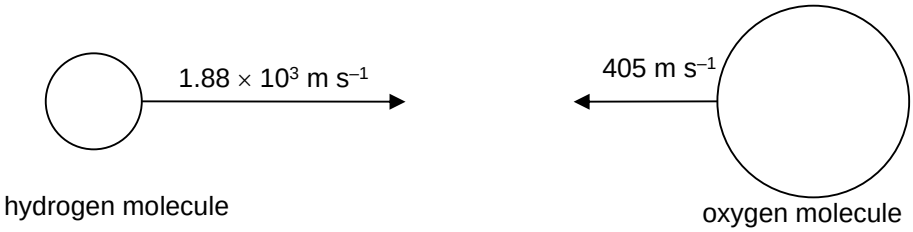


Fig. 4.1

In qualitative terms, what can be stated about the subsequent motion as a result of knowing that

(i) the collision is elastic,

(ii) the collision is head-on?

(b) Using your answers to **(a)**,

(i) determine the velocity of separation of the two molecules after the collision,

(ii) apply the law of conservation of momentum to the collision to determine the velocity of both molecules after the collision.

5 [2017 P3 Q2]

Two frictionless trolleys A and B approach each other along a horizontal straight line, as illustrated in Fig. 5.1.

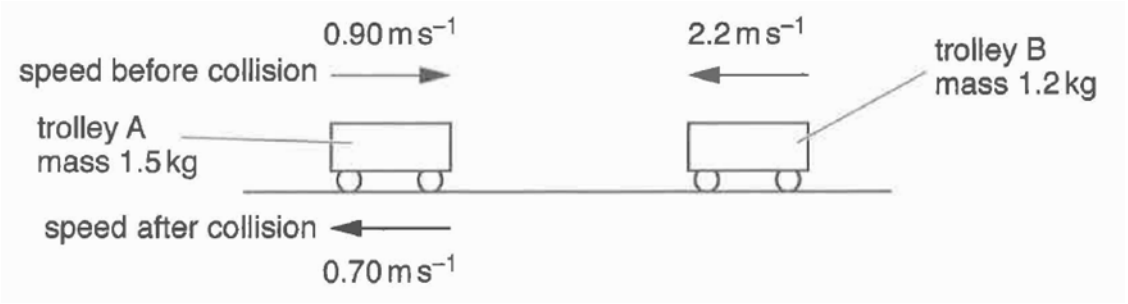


Fig. 5.1

Trolley A has mass 1.5 kg and is moving towards trolley B with a speed of 0.90 m s^{-1}. Trolley B has mass 1.2 kg and moves towards trolley A with a speed of 2.2 m s^{-1}.

The trolleys collide and are in contact for a time of 0.30 s.

Trolley A reverses its direction of motion and moves off with a speed of 0.70 m s^{-1}.

(a) For the time during the collision,
(i) suggest and explain whether both trolleys could be stationary at the same time,
(ii) calculate the average force F between the trolleys.

(b) **(i)** Use your answer in **(a)(ii)** to calculate the speed of trolley B after the collision.
(iii) Use your answer in to state and explain the direction of the motion of trolley B.

(c) By considering quantitatively, the relative speed of approach and of separation of the two trolleys, deduce whether the collision is elastic or inelastic.

Answers to selected questions:	
2(b)	15 m s^{-1}, –1.5 m s^{-1}
3(b)	0.2*v*
3(c)	0.6*v*, 1.4*v*
4(b)(i)	2285 m s^{-1}
4(b)(ii)	2420 m s^{-1}, 136 m s^{-1}
5(a)(ii)	– 8.0 N
5(b)(i)	0.2 m s^{-1}