Basic exercise Multiple-choice

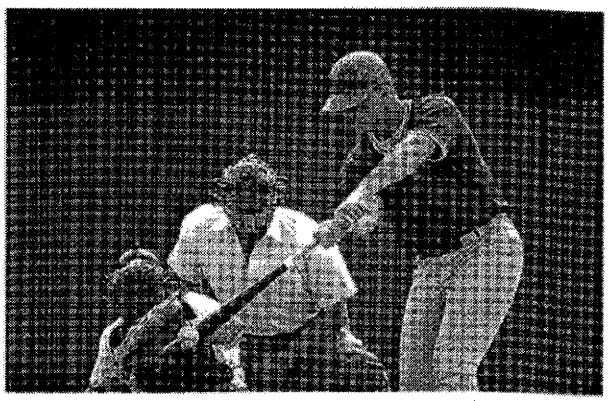
8.1

1 Wilson of mass 60 kg runs at 2 m s^{-1} towards right. Peggy of mass 40 kg runs at 3 m s^{-1} towards left. Which of the following statements is **correct**?

A Peggy has a greater momentum.
B They have different momentum.
C They have same momentum.
D Cannot be compared.

B

(For Q2–3.) A baseball of mass 0.15 kg flies at 30 m s^{-1} horizontally towards a player. It is hit and flies at 40 m s^{-1} in opposite direction. Take the direction of the ball towards the player as positive.



2 Find the change in momentum of the ball.

A −10.5 kg m s^{-1}
B −6 kg m s^{-1}
C 1.5 kg m s^{-1}
D 4.5 kg m s^{-1}

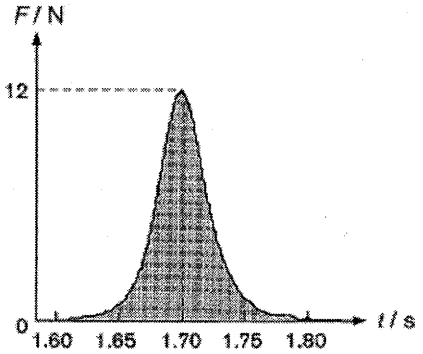
A

3 If the time of impact is 0.05 s, find the average force acting on the ball.

A −210 N
B −90 N
C 30 N
D 120 N

A

(For Q4–5.) A trolley hits a force sensor and rebounds. The figure below shows the *F*–*t* graph obtained. The area under the graph is 0.39 N s.



4 Find the change in momentum of the trolley.

A 0.39 kg m s^{-1}
B 2.4 kg m s^{-1}
C 12 kg m s^{-1}
D 20.4 kg m s^{-1}

A

5 Find the average force acting on the trolley during impact.

A 0.39 N
B 1.95 N
C 7.06 N
D 12 N

B

6 Which of the following equipment can reduce injuries to boxers in boxing?

(1) Head gear
(2) Hand wrap
(3) Mouthpiece

A (1) only
B (1) and (2) only
C (2) and (3) only
D (1), (2) and (3)

D

★7 Statements: (For instructions, see inside back cover.)

1st statement: An object with larger mass must have a larger momentum.

2nd statement: The momentum of an object depends on the mass and velocity of the object.

D

★8 Statements: (For instructions, see inside back cover.)

1st statement: Crumple zone in the front and rear sections of a car collapses in a serious traffic accident to reduce injuries to driver.

2nd statement: When crumple zone collapses, the time of impact is lengthened and the force of impact is reduced.

A

8.2

9 A bullet of mass 15 g is fired towards right from a rifle of mass 4 kg. If the speed of the bullet is 160 m s^{-1}, find the recoil velocity of the rifle.

A 0.6 m s^{-1} (towards right)
B 0.6 m s^{-1} (towards left)
C 6 m s^{-1} (towards right)
D 6 m s^{-1} (towards left)

B

10 Car *A* of mass 1500 kg moves at a speed of 15 m s^{-1} towards right. Car *B* of mass 1000 kg moves at a speed of 25 m s^{-1} towards left. After a head-on collision, the two cars stick together. Find their common velocity after collision.

A 1 m s^{-1} (towards right)
B 1 m s^{-1} (towards left)
C 19 m s^{-1} (towards right)
D 19 m s^{-1} (towards left)

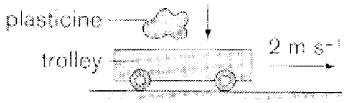
B

11 Ball *A* moves at a speed of 0.4 m s^{-1} towards right. It collides with a stationary ball *B*. After collision, *B* moves at a speed of 0.3 m s^{-1} towards right. If the masses of *A* and *B* are 3 kg and 2 kg respectively, find the velocity of *A* after collision.

A 0.05 m s^{-1} (towards left)
B 0.2 m s^{-1} (towards left)
C 0.2 m s^{-1} (towards right)
D 0.6 m s^{-1} (towards right)

C

12

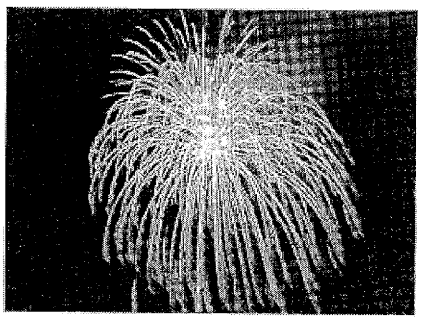


A trolley moves at a speed of 2 m s^{-1}. A lump of plasticine of mass 0.25 kg falls on it. The mass of the trolley is 1 kg. Find the speed of the trolley after the plasticine sticks to it.

A 1.6 m s^{-1} B 1.79 m s^{-1}
C 1.8 m s^{-1} D 2 m s^{-1}

A

13

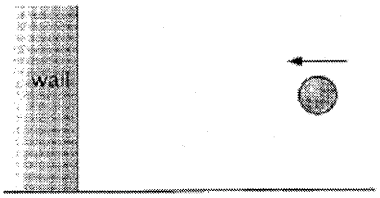


Pieces of firework always fly in all directions. Which of the following best explains this phenomenon?

A High temperature causes convection of gases.
B This kind of firework is popular.
C The total momentum of each firework is zero before explosion.
D The chemical energy of the firework is converted to heat, sound and light energy.

C

★14



A cannon travels towards a wall at a constant horizontal speed. It embeds itself in the wall and stops. Which of the following statements is/are **correct**?

(1) The total momentum of the cannon and the wall before collision is equal to that after collision.

(2) As the cannon embeds itself in the wall, there is external force acting on the cannon and the wall.

(3) The total mass of the wall and the Earth is very large. Their change in momentum is difficult to detect.

A (1) only
B (1) and (2) only
C (2) and (3) only
D (1) and (3) only

D

★15 Statements: (For instructions, see inside back cover.)

1st statement: In completely inelastic collision, the speeds of two colliding objects can be zero.

2nd statement: The law of conservation of momentum does not apply to completely inelastic collision.

C

★16 Statements: (For instructions, see inside back cover.)

1st statement: In a head-on collision, colliding objects of different masses have different changes in momentum.

2nd statement: If no external force acts on colliding objects, their total momentum before collision is equal to that after collision.

B

Basic exercise — Short questions

8.1

1 Calculate the momentum of each object below. Take the direction towards right as positive.

(a) A bullet of mass 0.02 kg flies at 200 m s^{-1} towards right. (1 mark)

$p = (0.02)(200) = +4$ kg m s^{-1}

(b) A lorry of mass 5000 kg travels at 16 m s^{-1} towards right. (1 mark)

$p = (5000)(16) = +8 \times 10^4$ kg m s^{-1}

(c) A football of mass of 0.4 kg travels at 3 m s^{-1} towards left. (1 mark)

$p = (0.4)(-3) = -1.2$ kg m s^{-1}

2 Calculate the change in momentum of each object below. Complete the following table. (3 marks)

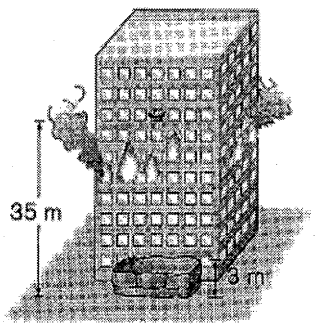
	Object	Mass m (kg)	Initial velocity u (m s^{-1})	Final velocity v (m s^{-1})	Change in momentum (kg m s^{-1})
(a)	Sports car	1000	30	10	$1000(10-30) = -2 \times 10^4$
(b)	Bullet	0.01	100	80	$0.01(80-100) = -0.2$
(c)	Ball	0.1	5	0	$0.1(0-5) = -0.5$

3 Calculate the average force acting on each object below. Complete the following table. (3 marks)

$F = \frac{\Delta p}{t}$

	Object	Mass m (kg)	Initial velocity u (m s^{-1})	Final velocity v (m s^{-1})	Time of impact t (s)	Average force F (N)
(a)	Basketball	0.45	12	0	0.6	$\frac{0.45(0-12)}{0.6} = -9$
(b)	Falling object	0.2	30	0	0.015	$\frac{0.2(0-30)}{0.015} = -400$
(c)	Lorry	3000	18	0	1	$\frac{3000(0-18)}{1} = -54000$

★4 A fire breaks out in a building. Ken of mass 50 kg jumps down from a height of 35 m. He falls on a rescue cushion and stops in 0.18 s. The cushion is 3 m high after inflation. Assume air resistance is negligible.



Take downward as +ve

(b) Average net force during the 3-m fall

$F_{net} = \frac{50(0-25.3)}{0.18} = -7027.8$

∴ Average force by cushion $= -7027.8 - 500 = 7527.8$

(a) Find the speed of Ken when he reaches the cushion. (2 marks)

By $v^2 = u^2 + 2gs$, $v^2 = 0^2 + 2(10)(35-3)$ ∴ $v = 25.3$ m s^{-1}

(b) Find the average force exerted by the cushion on Ken. (2 marks)

★5 At lift-off, a rocket pushes out 8000 kg of hot gas each second. The speed of the ejected gas is 2500 m s^{-1}. Find the thrust of the rocket at lift-off. (3 marks)

For gas. $F = \Delta p/\Delta t$

Force on gas $= (8000)(2500)/1$

$= 2 \times 10^7$ N (downward)

By newton's third Law, thrust on rocket by gas $= 2 \times 10^7$ N (upward

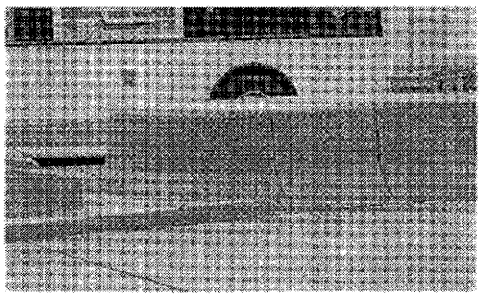
★6 A car of 1600 kg hits a barrier on roadside at 25 m s^{-1} and stops. Take the direction of motion of the car as positive.

(a) Find the change in momentum of the car. (2 marks)

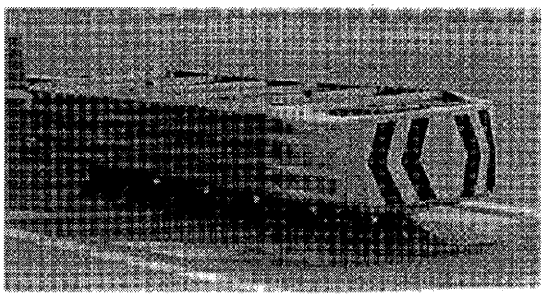
$\Delta p = (0 - 25)(1600)$

$= -4 \times 10^4$ kgms^{-1}

(b) Find the average force acting on the car in each of the following situations.



Concrete barrier (石屎欄)



Crash cushion system (摺疊式防撞欄)

(i) The car hits a concrete barrier and stops in 0.08 s. (2 marks)

$F = \Delta p/t = -4 \times 10^4/0.08$

$= -5 \times 10^5$ N

(ii) The car hits a crash cushion system and stops in 1.2 s. (2 marks)

$F = -4 \times 10^4/1.2$

$= -3.3 \times 10^4$ N

(c) Concrete barriers are replaced by crash cushion system in many highways in Hong Kong. Explain briefly the advantages of using this system. (2 marks)

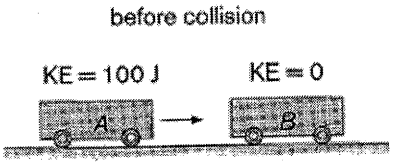
For crash cushion, a longer impact time results a small impact force. The degree of injury is reduced.

8.2

7 State a difference between kinetic energy of elastic and inelastic collisions. (2 marks)

Kinetic energy conserves in elastic collision but does not conserve in inelastic collision.

8 Before collision, kinetic energy of trolley *A* is 100 J and trolley *B* is at rest. State the type of collision in each of the following situations.



(a) After collision, the kinetic energy of *A* is 30 J and that of *B* is 70 J. (1 mark)

Elastic

(b) After collision, *A* stops while *B* travels forwards with kinetic energy of 50 J. (1 mark)

Inelastic

9 A trolley hits a wall with constant velocity. After collision, it stops in front of the wall. What type of collision is this? (1 mark)

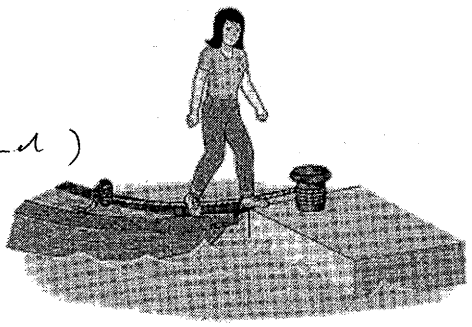
Inelastic

10 Teresa of mass 45 kg steps from a boat of mass 300 kg onto a bank. Initially, she and the boat are at rest. If she moves forwards at a speed of 2 m s^{-1} onto the bank, find the recoil speed of the boat. (2 marks)

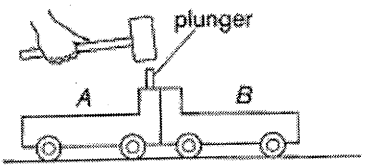
$0 = m_1u_1 + m_2u_2$

$= 45(2) + (300)(u_2)$

$\therefore u_2 = -0.3\ ms^{-1}$ (backward)



11 Trolley *A* of mass 2 kg and trolley *B* of 1 kg are in contact end-on. When the plunger is released, the two trolleys 'explode'. Trolley *A* travels at a speed of 0.3 m s^{-1} towards left.



(a) Is this an elastic collision? (1 mark)

Inelastic

(b) Find the velocity of trolley B after collision. (2 marks)

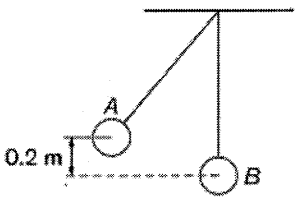
$0 = m_1u_1 + m_2u_2$

$= 2(0.3) + (1)(u_2)$

$\therefore u_2 = -0.6\ m s^{-1}$

(c) Find the increase in total momentum. (2 marks)

★12 Balls A and B are hung by two strings of equal length. Initially, ball A is pulled to one side 0.2 m above B and released while ball B is at rest. The mass of ball A is 1 kg.



(a) Find the speed of A before collision. (2 marks)

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$

$= \sqrt{2(10)(0.2)}$

$= 2\ m s^{-1}$

(b) A and B stick together after collision. If their speed immediately after collision is 1.6 m s^{-1}, find the mass of B. (2 marks)

By $m_A u_A = (m_A + m_B)V$

$(1)(2) = (1 + m_B)(1.6)$

$m_B = 0.25\ kg$

(c) What type of collision is this? Explain briefly. (3 marks)

K.E. before collision $= \frac{1}{2}(1)(2)^2 = 2\ J$

K.E. after collision $= \frac{1}{2}(1.25)(1.6)^2 = 1.6\ J$

K.E decreases $\therefore$ Inelastic collision has occurred

II Revision

Multiple-choice

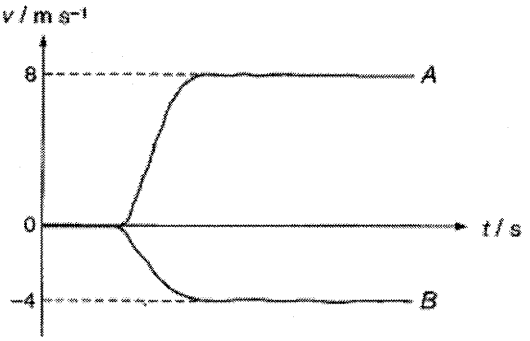
Section B

1 A tennis ball of mass 0.06 kg flies towards a racket at a speed of 15 m s^{-1}. It is hit and leaves the racket at a speed of 15 m s^{-1} in opposite direction. If the time of impact is 0.003 s, find the magnitude of the average force exerted by the racket on the ball.

A Zero B 300 N
C 600 N D 1000 N

C

2

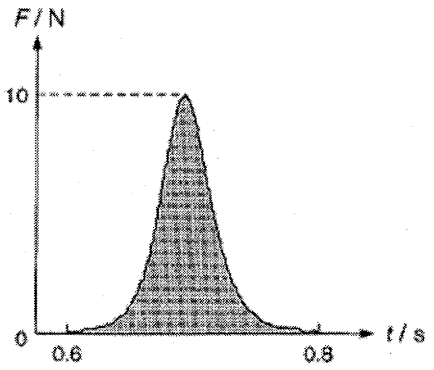


Trolleys *A* and *B* separate explosively. The figure above shows their *v*–*t* graph. The mass of *A* is 2 kg. Find the mass of *B*.

A 1 kg B 2 kg
C 4 kg D 8 kg

D

3



The figure above shows the *F*-*t* graph of a football when kicked. Which of the following statements are **correct**?

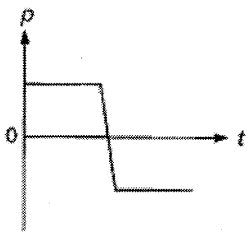
(1) The time of impact of the football is 0.02 s.
(2) The area under the *F*–*t* graph is equal to the change in momentum.
(3) The average force acting on the football is 10 N.

A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

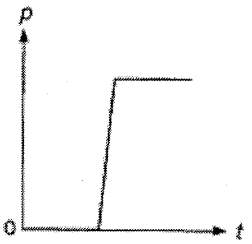
A

★4 A bomb explodes in a bar. Which of the following graphs shows the variation of the total momentum *p* of the bomb and the pub with time?

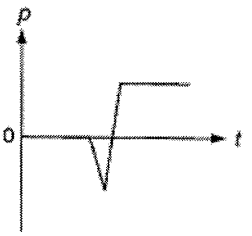
A



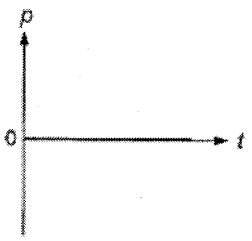
B



C

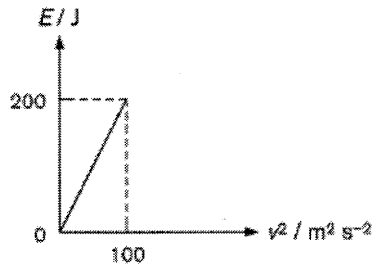


D



D

★5



The figure above shows the variation of kinetic energy E of an object with the square of its velocity v^2. When the object moves at a velocity of 3 m s^{-1}, find its momentum.

Helper: Find the mass of the object first.

A 3 kg m s^{-1}
B 6 kg m s^{-1}
C 9 kg m s^{-1}
D 12 kg m s^{-1}

D

★6 Statements: (For instructions, see inside back cover.)

1st statement: When we start to walk, our momentum increases.

2nd statement: When we start to walk, the total momentum of we and the Earth is conserved.

B

★7 Statements: (For instructions, see inside back cover.)

1st statement: When a lorry collides head-on with a minibus, the magnitude of the average force exerted by the lorry on the minibus is equal to that exerted by the minibus on the lorry.

2nd statement: When a lorry collides head-on with a minibus, the average force exerted by the lorry on the minibus and that exerted by the minibus on the lorry form an action-and-reaction pair.

A

Conventional

Section B

1 A car of mass 1000 kg accelerates uniformly at 1.5 m s^{-2} from rest along a straight road for 75 m. Take the forward direction as positive.

(a) Find the final velocity of the car. (2 marks)

By $v^2 = u^2 + 2as$

$v^2 = 2(1.5)(75)$

$v = +15$ m s^{-1}

(b) Find the final momentum of the car. (2 marks)

$p = 1000(15) = 15000$ kg m s^{-1}

2 Ball A moves at 3 m s^{-1} towards right and hits a stationary ball B. After collision, ball A moves at 1 m s^{-1} towards right. The masses of balls A and B are 2 kg and 1 kg respectively.

(a) Find the speed of ball B after collision. (2 marks)

By $m_A u_A = m_B v_B + m_A v_A$

$2(3) = (1)v_B + 2(1)$

$\therefore v_B = 4 \text{ m s}^{-1}$

(b) Is this an elastic collision? Explain briefly. (3 marks)

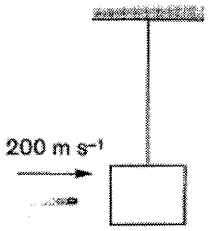
Initial K.E. $= \frac{1}{2}(2)(3)^2 = 9 \text{ J}$

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

$= 9 \text{ J}$

Elastic collision as K.E. conserves

★3 A wooden block of mass 2 kg is hung in air by a string. A bullet of mass 0.01 kg is fired horizontally at a speed of 200 m s^{-1} and hits the block. It embeds itself in the block and moves upwards together with it.



(a) Find the common velocity of the bullet and the block immediately after the bullet embeds itself in the block. (2 marks)

By $m_A u_A = (m_A + m_B)v$

$0.01(200) = (0.01 + 2)v$

$v = 0.995 \text{ m s}^{-1}$

(b) Find the height that the block rises. (2 marks)

By Conservation of K.E. & P.E.

$\frac{1}{2}(m_A + m_B)v^2 = (m_A + m_B)gh$

$\frac{1}{2}(2 + 0.01)(0.995)^2 = (2 + 0.01)(10)h$

$\therefore h = 0.0495 \text{ m}$

(c) Describe the energy change in the whole process. (2 marks)

K.E. of bullet → K.E of block & bullet + Internal energy of block

→ P.E of block & bullet.

★4 A golf player strikes a stationary goal ball. The ball moves at a speed of 50 m s^{-1} when struck and its mass is 0.04 kg. The time of impact between the club and the ball is 0.001 s.

(a) Find the average force acting on the ball. (2 marks)

$F = \Delta p / t = 0.04(50) / 0.001$

$= 2000\ N$

(b) Suggest a way to increase the impulse acting on the ball. (1 mark)

to strike the ball through for a longer impact time.

★5 Read the following passage and answer the questions that follow.

Car safety

To improve car safety, the front and the rear sections of a car are designed to collapse during collision. The strong middle passenger section of the car protects the driver and passengers from injuries from the collapsing car body.

Another safety measure is air-bag. It works within the space between the front seats and the steering wheel or the windscreen of the car. During collision, air-bags will be inflated within fractions of a second. This prevents the driver and front passenger from hitting the interior of the car. It also increases the time for them to come to stop.

(a) Briefly explain how the collapsible parts of the car can reduce the force of impact during collision. (2 marks)

The collapsible parts will lengthen the time of impact. By $F = \Delta p / t$, a long impact time can reduce the average force of impact.

(b) Besides the collapsible parts and air-bag, name and describe another safety measure in a car to protect drivers and passengers during collision. (3 marks)

A seat belt can help. It prevents the passenger from hitting the windscreen as the passenger will surely move forward due to inertia. The seat belt can also stretch a bit to increase the impact time and hence reduce the impact force.