MOMENTUM

1 A footballer kicks a ball vertically upwards. Initially, the ball is stationary.

(a) His boot is in contact with the ball for 0.050 s. The average resultant force on the ball during this time is 180 N. The ball leaves his foot at 20 m / s.

Calculate

(i) the impulse of the force acting on the ball,

impulse = ...[2]

(ii) the mass of the ball,

mass = ...[2]

(iii) the height to which the ball rises. Ignore air resistance.

height = ...[3]

(b) While the boot is in contact with the ball, the ball is no longer spherical.

State the word used to describe the energy stored in the ball.

.....[1]

[Total: 8]

MARKING SCHEME:

(a)(i)	Ft OR 180×0.050	**C1**
	9.0 Ns OR 9.0 kg m / s	**A1**
(a)(ii)	$Ft = m(v - u)$ OR $Ft = mv - mu$ OR $Ft = mv$ OR (m =) Ft / v OR 9.0 / 20	**C1**
	0.45 kg	**A1**
(a)(iii)	$mgh = ½ mv^2$ OR $(h =) v^2/2g$	**C1**
	$(h =) 20^2 / (2 \times 10)$	**C1**
	20 m	**A1**
	OR $t = v/g = 2$	**(C1)**
	h = average speed × time	**(C1)**
	20 m	**(A1)**
(b)	Elastic (energy) OR strain (energy)	**B1**
	Total:	**8**

2 **(a)** Underline the pair of quantities which must be multiplied together to calculate *impulse*.

force and mass	force and velocity	mass and time
time and velocity	weight and velocity	force and time

[1]

(b) Fig. 3.1 shows a collision between two blocks A and B on a smooth, horizontal surface.

before collision

after collision

Fig. 3.1

Before the collision, block A, of mass 2.4 kg, is moving at 3.0 m/s. Block B, of mass 1.2 kg, is at rest.

After the collision, blocks A and B stick together and move with velocity *v*.

(i) Calculate

1. the momentum of block A before the collision,

7

momentum = ...[2]

2. the velocity *v*,

velocity = ...[2]

3. the impulse experienced by block B during the collision.

impulse = ...[2]

(ii) Suggest why the total kinetic energy of blocks A and B after the collision is less than the kinetic energy of block A before the collision.

.....

.....[1]

[Total: 8]

MARKING SCHEME:

(a)	'force and time'	**B1**
(b)(i)1.	(momentum =) mv	**C1**
	(momentum = 2.4 × 3 =) 7.2 kg m / s OR Ns	**A1**
(b)(i)2.	$(m_A + m_B)v = m_A$ x 3 OR momentum conserved	**C1**
	(v = 7.2 / 3.6 =) 2.0 m / s	**A1**
(b)(i)3.	(impulse / Ft =) m(v – u)	**C1**
	(impulse / Ft = 1.2 × (2–0) =) 2.4 kg m / s OR N s	**A1**
(b)(ii)	thermal/sound energy (produced at collision/lost)	**B1**
	Total:	**8**

3 **(a)** State the word equation that defines *momentum*.

.....[1]

(b) A metal block A, travelling in a straight line at 4.0 m/s on a smooth surface, collides with a second metal block B which is at rest. Fig. 2.1 shows the two metal blocks A and B before and after the collision.

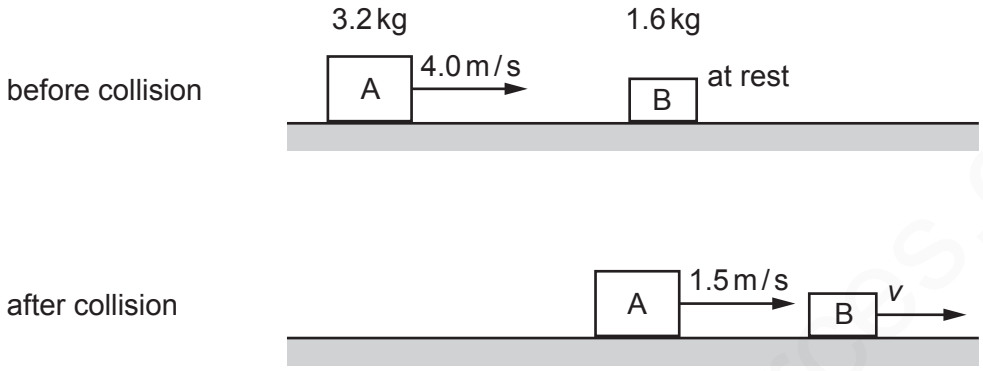

Fig. 2.1

The mass of A is 3.2 kg. The mass of B is 1.6 kg.
After the collision, the velocity of A is 1.5 m/s.

Calculate

(i) the momentum of A before the collision,

momentum = ...[2]

(ii) the velocity *v* of B after the collision.

v = ...[3]

In the collision that occured in (b), block A and block B are in contact for 0.050s

Calculate the average force that is exerted on B during the collision.

average force = ...[2]

(d) After the collision in **(b)**, the total kinetic energy of the two blocks is less than the kinetic energy of block A before the collision.

Suggest **one** reason for this.

.....

.....[1]

[Total: 9]

MARKING SCHEME:

(a)	(momentum =)mass × velocity	**B1**
(b)(i)	(p =)3.2 × 4.0	**C1**
	13 kg m / s	**A1**
(b)(ii)	momentum conserved	**C1**
	12.8 – (3.2 × 1.5) OR 12.8 – 4.8 OR 8.0 OR 8.0 ÷ 1.6	**C1**
	5.0 m / s	**A1**
(c)	(F =) $\frac{\Delta p}{\Delta t}$ **or** 8.0 ÷ 0.050	**C1**
	160 N	**A1**
(d)	internal energy (of blocks) increase OR thermal energy/sound energy (lost/produced at collision)	**B1**
	Total:	**9**

4 Fig. 4.1 shows a balloon filled with helium that is used to lift measuring instruments to a great height above the Earth's surface.

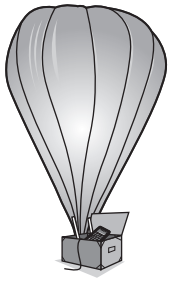

Fig. 4.1

(a) Explain, in terms of momentum, how the atoms of helium produce a force on the wall of the balloon.

.....

.....

.....

.....[3]

(b) At ground level, the pressure of the helium in the balloon is 1.0×10^5 Pa. The volume occupied by the helium is $9.6\,m^3$.

The balloon is released and it rises quickly through the atmosphere. The volume occupied by the helium increases, but the temperature of the helium may be assumed to stay constant.

(i) Explain, in terms of the helium atoms in the balloon, why the pressure in the balloon is smaller than at ground level.

.....

.....

.....[2]

(ii) Calculate the pressure of the helium when it occupies a volume of $12\,m^3$.

pressure = ...[2]

[Total: 7]

MARKING SCHEME:

(a)	Atoms collide with wall (and rebound) OR atoms rebound from wall	**B1**
	(Atoms) undergo change of momentum	**C1**
	Force on wall = (total) rate of change of momentum (of atoms) OR = change of momentum (of atoms) per second OR = change of momentum (of atoms) / time	**A1**
(b)(i)	Fewer atoms per unit volume OR density of gas less	**B1**
	Rate of collision (with walls of balloon) decreases OR Fewer collisions per unit area	**B1**
(b)(ii)	PV = constant OR $P_1V_2 = P_2V_2$ OR (P_2 =) P_1V_1 / V_2 OR $1.0 \times 10^5 \times 9.6 / 12$	**C1**
	8.0×10^4 Pa	**A1**