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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Momentum

Paper 2 — Theory / Structured Questions (topical compilation)

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0625/42/F/M/16/Q2

Fig. 2.1 shows a hammer being used to drive a nail into a piece of wood.

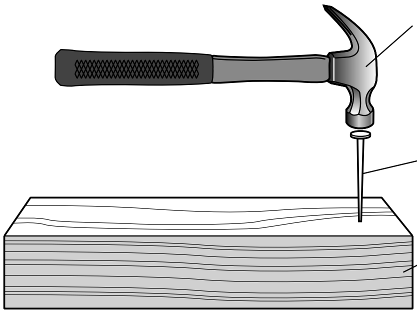

Fig. 2.1

The mass of the hammer head is 0.15 kg.
The speed of the hammer head when it hits the nail is 8.0 m/s.
The time for which the hammer head is in contact with the nail is 0.0015 s.

The hammer head stops after hitting the nail.

(a) Calculate the change in momentum of the hammer head.

change in momentum = ...[2]

(b) State the impulse given to the nail.

impulse = ...[1]

(c) Calculate the average force between the hammer and the nail.

average force = ...[2]

[Total: 5]

(c) A different car has a mass of 1500 kg. It collides with the same wall and all of the energy transferred during the collision is absorbed by the crumple zone.

(i) The energy absorbed by the crumple zone is 4.3×10^5 J. Show that the speed of the car before the collision is 24 m / s.

[2]

(ii) Suggest what would happen to the car if it is travelling faster than 24 m / s when it hits the wall.

....

....[1]

[Total: 8]

0625/41/2016/Q2

Fig. 2.1 shows a dummy of mass 70 kg used in a crash test to investigate the safety of a new car.

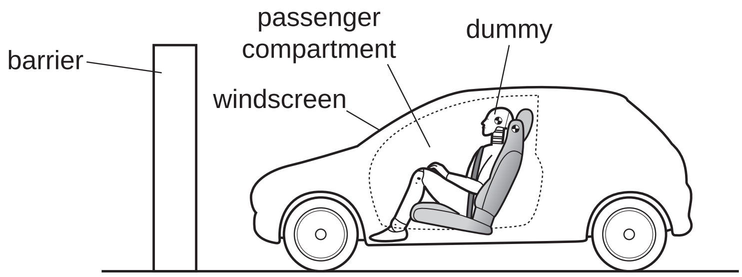

Fig. 2.1

The car approaches a solid barrier at 20 m / s. It crashes into the barrier and stops suddenly.

(a) **(i)** Calculate the momentum of the dummy immediately before the crash.

momentum = ... [2]

(ii) Determine the impulse that must be applied to the dummy to bring it to rest.

impulse = ... [1]

(b) In the crash test, the passenger compartment comes to rest in 0.20 s.

Calculate the deceleration of the passenger compartment.

deceleration = ... [2]

(c) The seat belt and air bag bring the dummy to rest so that it does not hit the windscreen. The dummy has an average deceleration of 80 m/s^2.

Calculate the average resultant force applied to the dummy, of mass 70 kg.

force = ... [2]

(d) The deceleration of the dummy is less than the deceleration of the passenger compartment.

Explain why this is of benefit for the safety of a passenger.

....

....

....

....

....

.... [2]

[Total: 9]

0625/42/2016/Q2

Fig. 2.1 shows two railway trucks on a track.

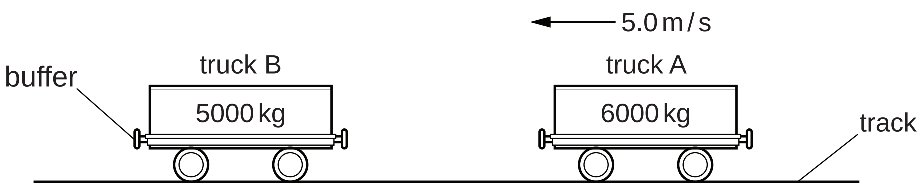

Fig. 2.1

Truck A of mass 6000 kg is moving at 5.0 m / s. It is approaching truck B of mass 5000 kg, which is stationary.

(a) Calculate the momentum of truck A.

momentum = ... [2]

(b) The trucks collide, their buffers compress and then they bounce off each other, remaining undamaged.

After the collision, truck B has a momentum of 27 000 kg m / s.

(i) Determine the impulse applied to truck B.

impulse = ... [2]

(ii) The trucks are in contact for 0.60 s.

Calculate the average force on truck B.

force = ... [2]

(iii) Calculate the final speed of truck A.

speed = ... [3]

[Total: 9]

0625/43/2016/Q2

Fig. 2.1 shows two cars, A and B, before they collide.

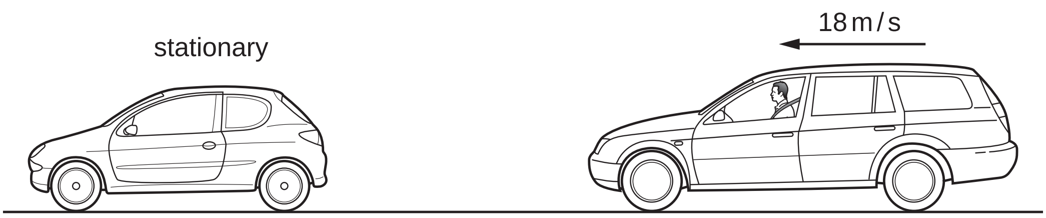

Fig. 2.1

Car B, of mass 1200 kg, is stationary. Car A, of mass 2000 kg, is travelling towards car B at 18 m / s.

(a) Calculate the momentum of car A.

momentum = ... [2]

(b) The cars collide and car B experiences an impulse. Car A continues to move in the same direction, with a momentum of 21 000 kg m / s.

(i) Calculate the momentum of car B immediately after the collision.

momentum = ... [1]

(ii) Determine the average impulse experienced by car B during the collision.

impulse = ... [1]

(iii) The cars are in contact for 0.20 s.

Calculate the average resultant force experienced by car B during the collision.

force = ... [2]

(c) A modern car is designed so that, during a collision, the front section of the car is crushed and the time of contact increases.

Explain the benefit of increasing the time of contact for the people in the car.

....

....

....

.... [2]

[Total: 8]

0625/41/M/J/17/Q2

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]

0625/42/M/J/17/Q3

(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.

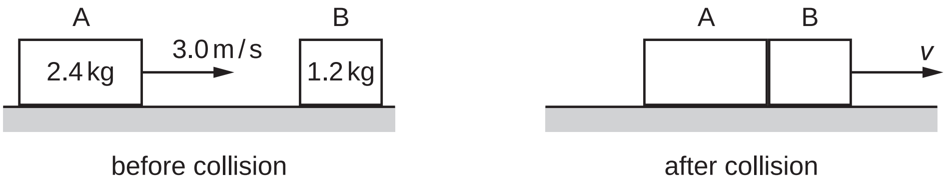

Fig. 3.1

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,

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]

0625/43/M/J/17/Q2

(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.

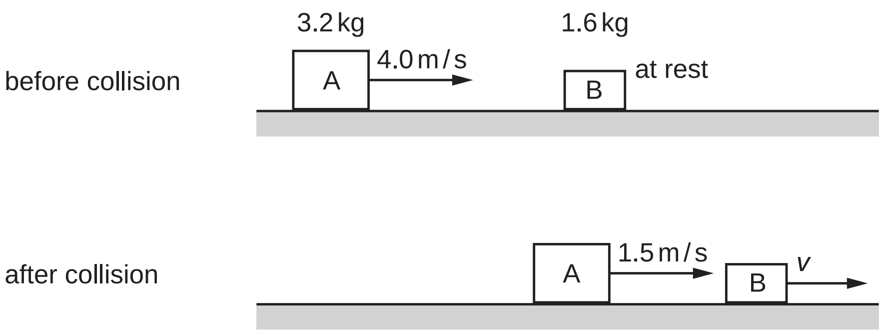

Fig. 2.1

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]

(c) In the collision that occurred in **(b)**, block A and block B are in contact for 0.050 s.

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]

0625/41/M/J/19/ Q1

A rocket is stationary on the launchpad. At time $t = 0$, the rocket engines are switched on and exhaust gases are ejected from the nozzles of the engines. The rocket accelerates upwards.

Fig. 1.1 shows how the acceleration of the rocket varies between time $t = 0$ and time $t = t_f$.

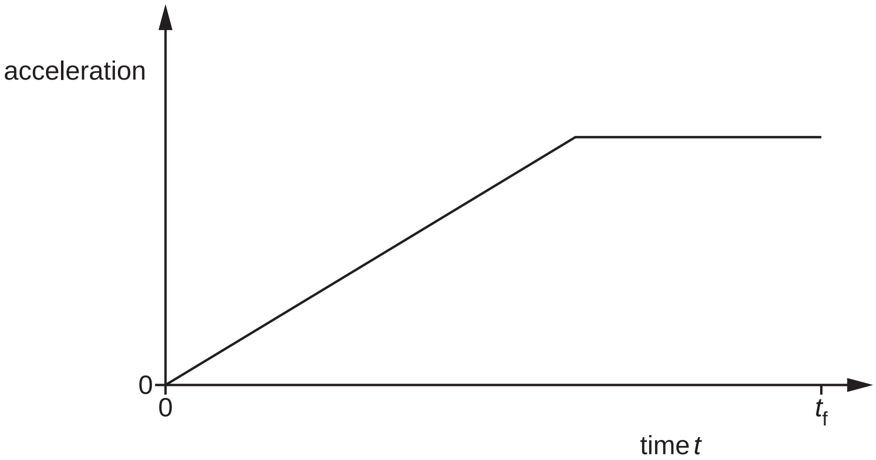

Fig. 1.1

(a) Define *acceleration*.

....

.... [1]

(b) On Fig. 1.2, sketch a graph to show how the speed of the rocket varies between time $t = 0$ and time $t = t_f$.

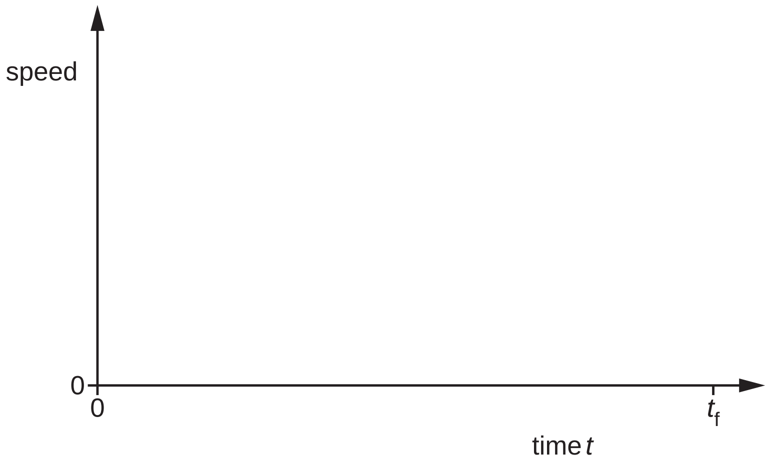

Fig. 1.2

[3]

(c) Some time later, the rocket is far from the Earth. The effect of the Earth's gravity on the motion of the rocket is insignificant. As the rocket accelerates, its momentum increases.

(i) State the principle of the conservation of momentum.

....

....

.... [2]

(ii) Explain how the principle of the conservation of momentum applies to the accelerating rocket and the exhaust gases.

....

....

....

.... [2]

[Total: 8]

0625/42/M/J/19/Q2

Fig. 2.1 shows a model fire engine. Its brakes are applied.

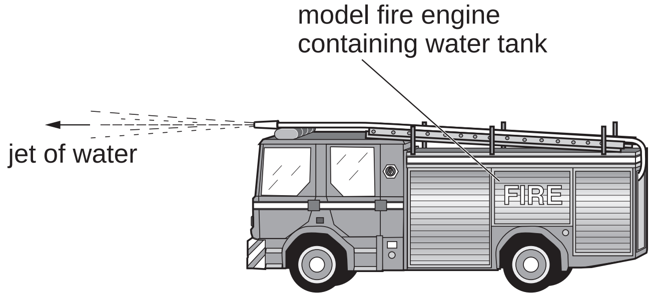

Fig. 2.1

0.80 kg of water is emitted in the jet every 6.0 s at a velocity of 0.72 m/s relative to the model.

(a) Calculate the change in momentum of the water that is ejected in 6.0 s.

momentum = ... [2]

(b) Calculate the magnitude of the force acting on the model because of the jet of water.

force = ... [2]

(c) The brakes of the model are released.

State and explain the direction of the acceleration of the model.

Statement ....

Explanation ....

.... [2]

(d) In **(c)** the model contains a water tank, which is initially full.

State and explain any change in the magnitude of the initial acceleration if the brakes are first released when the tank is nearly empty.

Statement ....

Explanation ....

....

.... [3]

[Total: 9]

0625/42/O/N/16/Q2

(a) **(i)** State an expression for the kinetic energy of an object of mass *m* that is moving with a speed *v*.

.... [1]

(ii) State and explain whether kinetic energy is a scalar quantity or a vector quantity.

.... [1]

(b) Fig. 2.1 shows two fairground "bumper" cars.

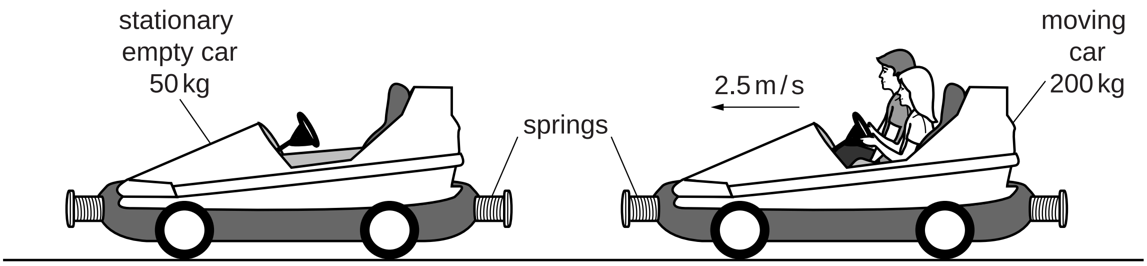

Fig. 2.1

The car with passengers, of total mass 200 kg, is moving in a straight line. It is travelling at 2.5 m/s when it hits a stationary empty car of mass 50 kg.

After the collision, the empty car moves forwards in the same direction at a speed of 4.0 m/s.

For the car with passengers, determine

(i) its momentum when it is travelling at 2.5 m/s,

momentum = ... [2]

(ii) the speed and direction of its motion immediately after the collision.

speed = ...

direction: ....
[3]

(iii) Fixed to the front and the back of the cars are large springs.

When the cars collide the springs compress.

The total kinetic energy of the cars after the collision is equal to the total kinetic energy before the collision.

Describe the energy transfers that occur as the cars collide and then separate.

....

....

.... [2]

[Total: 9]

0625/43/O/N/16/Q3

(a) **(i)** State how a *vector* quantity differs from a *scalar* quantity.

....

.... [1]

(ii) State and explain whether *momentum* is a vector quantity or a scalar quantity.

....

.... [1]

(b) A spacecraft of mass 35 kg is travelling in a straight line at a velocity of 1200 m/s. Assume no external forces act on the spacecraft.

Calculate

(i) the momentum of the spacecraft,

momentum = ... [2]

(ii) the kinetic energy of the spacecraft.

kinetic energy = ... [2]

(c) The rocket fuel stored in the moving spacecraft in **(b)** explodes and the spacecraft splits into two sections. One section speeds up and the other section slows down.

(i) State what happens to the total momentum.

.... [1]

(ii) Predict and explain what happens to the total kinetic energy.

....

.... [2]

[Total: 9]

0625/41/O/N/18/Q3

(a) State what is meant by *the principle of conservation of energy*.

....

....[1]

(b) Fig. 3.1 shows a girl throwing a heavy ball.

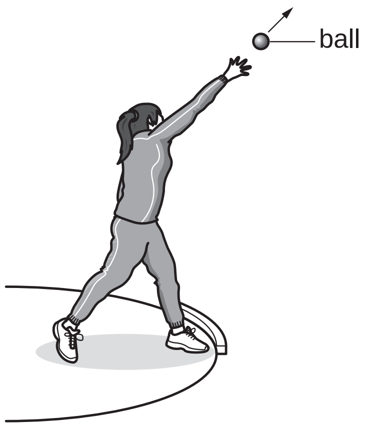

Fig. 3.1

(i) State the energy changes that take place from when the girl begins to exert a force on the ball until the ball hits the ground and stops moving.

....

....

....

....

....[2]

(ii) The mass of the ball is 4.0 kg. The girl exerts a force on the ball for 0.60 s. The speed of the ball increases from 0 m/s to 12 m/s before it leaves the girl's hand.

Calculate:

1. the momentum of the ball on leaving the girl's hand

momentum = ...[2]

2. the average resultant force exerted on the ball.

average resultant force = ...[2]

[Total: 7]

0625/42/O/N/18/Q3

(a) The velocity of an object of mass *m* increases from *u* to *v*.

State, in terms of *m*, *u* and *v*, the change of momentum of the object.

....[1]

(b) In a game of tennis, a player hits a stationary ball with his racquet.

(i) The racquet is in contact with the ball for 6.0 ms. The average force on the ball during this time is 400 N.

Calculate the impulse on the tennis ball.

impulse = ...[2]

(ii) The mass of the ball is 0.056 kg.

Calculate the speed with which the ball leaves the racquet.

speed = ...[2]

(iii) State the energy transfer that takes place:

1. as the ball changes shape during the contact between the racquet and the ball

....

....

2. as the ball leaves the racquet.

....

....
[2]

[Total: 7]

0625/43/O/N/18/Q2

(a) Complete Fig. 2.1 by writing in the right-hand column the name of the quantity given by the product in the left-hand column.

product	quantity
mass × acceleration	
force × time	

[2]

Fig. 2.1

(b) Fig. 2.2 shows a man hitting a ball with a golf club.

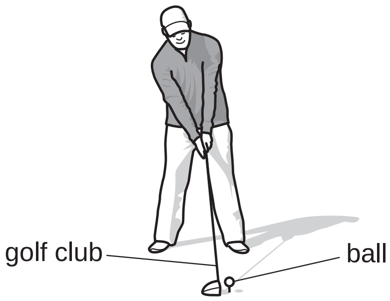

Fig. 2.2

The ball has a mass of 0.046 kg. The golf club is in contact with the ball for 5.0×10^{-4} s and the ball leaves the golf club at a speed of 65 m/s.

(i) Calculate:

1. the momentum of the ball as it leaves the golf club

momentum = ...[2]

2. the average resultant force acting on the ball while it is in contact with the golf club.

average force = ...[2]

(ii) While the golf club is in contact with the ball, the ball becomes compressed and changes shape.

State the type of energy stored in the ball during its contact with the golf club.

....[1]

[Total: 7]

0625/41/O/N/19/Q3

Fig. 3.1 shows a shooting competition, where air rifles fire soft metal pellets at distant targets.

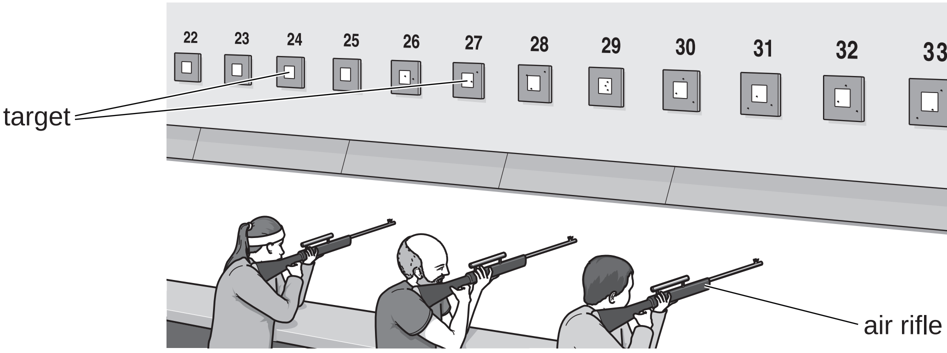

Fig. 3.1

When an air rifle is fired, it exerts an impulse of 0.019 N s on the pellet.

(a) Define *impulse*.

....

.... [1]

(b) The pellet has a mass of 1.1×10^{-4} kg.

Determine:

(i) the speed with which the pellet leaves the rifle

speed = ... [2]

(ii) the kinetic energy of the pellet as it leaves the rifle.

kinetic energy = ... [3]

(c) The pellet melts when it strikes the target.

Describe how the molecular structure of the liquid metal differs from that of the solid metal.

....

....

....

.... [3]

[Total: 9]