Momentum

Question Paper

Course	CIE IGCSE Physics
Section	1. Motion, Forces & Energy
Topic	Momentum
Difficulty	Hard

Time Allowed 70

Score /51

Percentage /100

Question 1a

Extended tier only

Fig. 2.1 shows an athlete crossing the finishing line in a race. As she crosses the finishing line, her speed is 10.0 m/s. She slows down to a speed of 4.0 m/s.

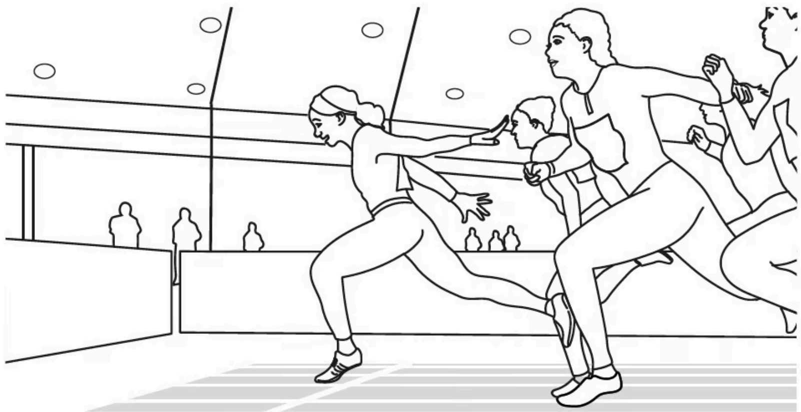

Fig. 2.1

The mass of the athlete is 71 kg. Calculate the impulse applied to her as she slows down. Give your answer to 2 significant figures.

impulse = ...
[3 marks]

Question 1b

Extended tier only

(i) Define impulse in terms of force and time.

[1]

(ii) The athlete takes 1.2 s to slow down from a speed of 10.0 m/s to a speed of 4.0 m/s.

Calculate the average resultant force applied to the athlete as she slows down.

force = ... [2]

[3 marks]

Question 1c

Extended tier only

Calculate the force required to give a mass of 71 kg an acceleration of 6.4 m/s^2.

force = ...

[2 marks]

Question 2a

Extended tier only

Fig. 2.1 shows a train.

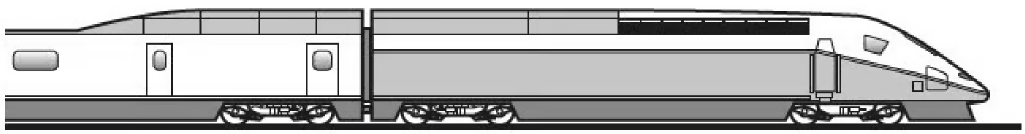

Fig. 2.1

The total mass of the train and its passengers is 750 000 kg. The train is travelling at a speed of 84 m/s. The driver applies the brakes and the train takes 80 s to slow down to a speed of 42 m/s.

Calculate the impulse applied to the train as it slows down.

impulse = ...

[3 marks]

Question 2b

Extended tier only

Calculate the average resultant force applied to the train as it slows down.

force = ...

[2 marks]

Question 2c

Suggest how the shape of the train helps it to travel at high speeds.

[1 mark]

Question 2d

The train took 80 s to reduce its speed from 84 m/s to 42 m/s. Explain why, with the same braking force, the train takes less than 80 s to reduce its speed from 42 m/s to zero.

[1 mark]

Question 2e

On a wet day, the train travels a greater distance before it stops along the same track. The train has the same speed of 84 m / s before the brakes are applied.

Suggest a reason for this.

[1 mark]

Question 3a

Extended tier only

Fig. 1 shows two railway trucks **A** and **B** travelling towards each other on the same railway line which is straight and horizontal.

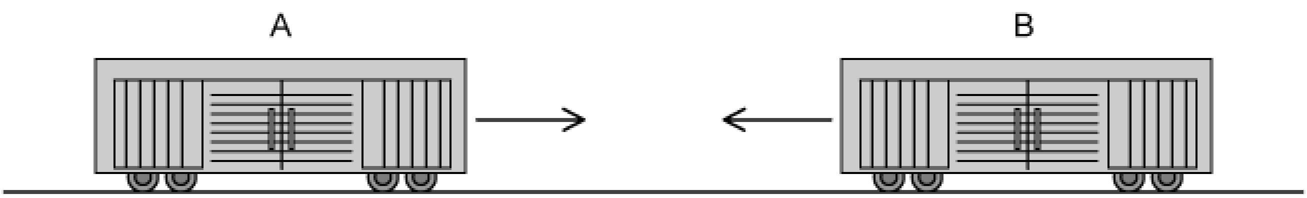

Fig. 1

The trucks are involved in a collision. They join when they collide and then move together.

Truck **A** has a total mass of 27 000 kg and truck **B** has a total mass of 22 000 kg.

Just before the collision, truck **A** was moving at a speed of 3.6 m s^{-1} and truck **B** was moving at a speed of 2.4 m s^{-1}.

Calculate the speed of the joined trucks immediately after the collision.

[4 marks]

Question 3b

Extended tier only

During the collision each truck experiences an impulse acting on it.

(i) Calculate the impulse that acts on each truck during the collision.

[2]

(ii) State two possible units for your answer.

[2]

[1 mark]

Question 3c

Extended tier only

The trucks come to a stop after 3.0 minutes.

Calculate the deceleration of the joined trucks.

[2 marks]

Question 3d

Explain why the trucks stop moving.

[2 marks]

Question 4a

Extended tier only

A shell, of mass 30 g, is fired from the barrel of a rifle, of mass 1.9 kg, with a momentum 36 kg m/s.

State the total momentum of the rifle and the bullet before the rifle is fired and give a reason for your answer.

[2 marks]

Question 4b

Extended tier only

Calculate the velocity of the shell just after the rifle is fired.

[3 marks]

Question 4c

Extended tier only

Continue to calculate for the moment just after the rifle has been fired.

(i) Use the principle of conservation of momentum, and your answer to part (a), to state the total momentum of the rifle and the shell.

[2]

(ii) Calculate the recoil momentum of the rifle.

[4]

[6 marks]

Question 4d

Extended tier only

The shell has a momentum of 9.8 kg m/s just before it hits a target.

It takes 4.5 ms for the bullet to the stopped by the target.

Calculate the average force needed to stop the bullet.

[4 marks]

Question 5a

Extended tier only

Until the second half of the 20th century, cars were designed as strong rigid boxes, which designers thought would protect passengers in accidents. In fact, although average speeds were much slower than today, passengers were often very badly injured.

Modern cars are designed with safety features including 'crumple zones'. The crumple zones are at the front and rear of the car but do not include the passenger section. In a crash, the crumple zone is designed so that it deforms and bends. This is shown in Fig. 1.1.

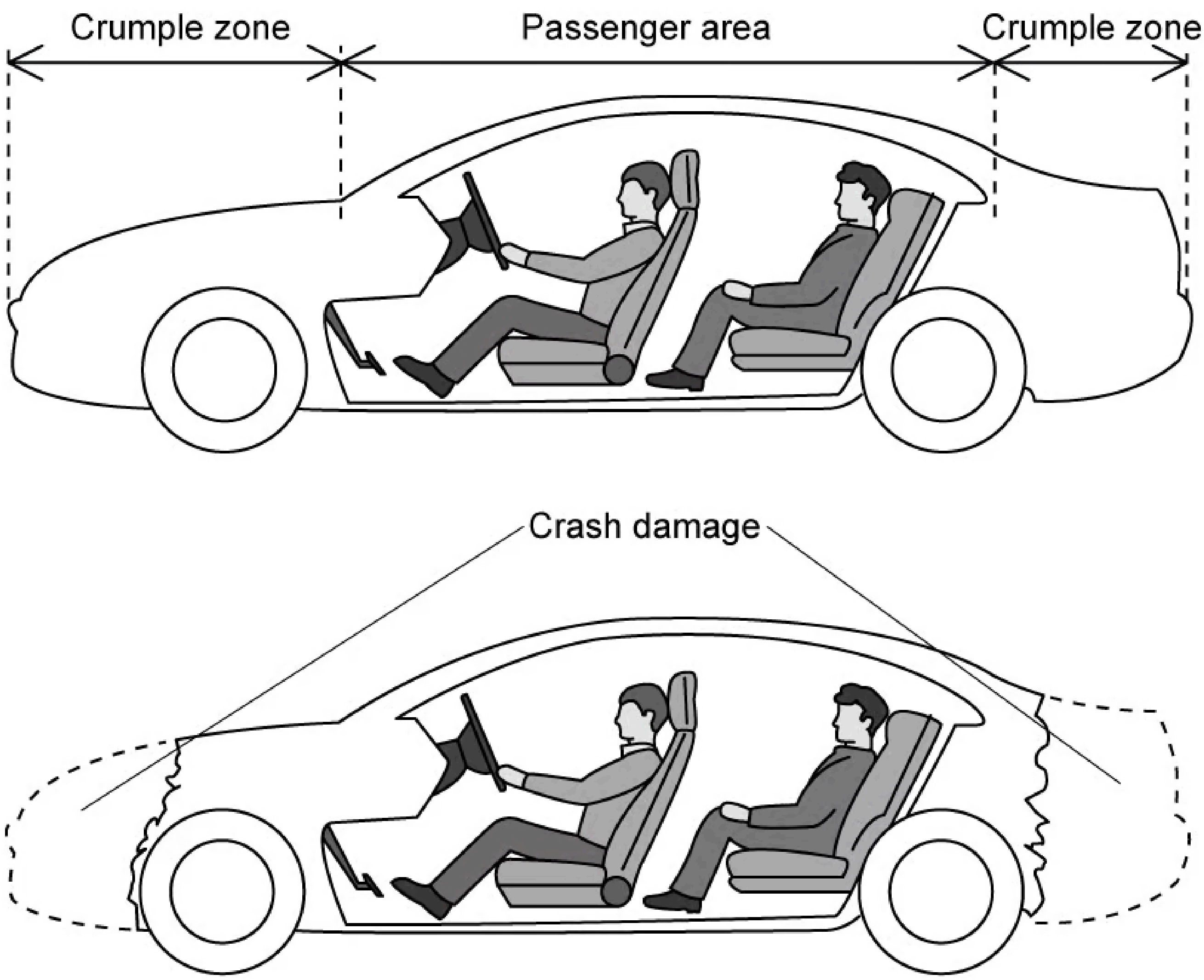

Fig. 1.1

The use of crumple zones explains why the front and rear of cars are badly damaged during accidents.

Use your knowledge of momentum and impulse forces to suggest why a car with a crumple zone protects the driver and passengers from serious injury better than one which is a strong, rigid box.

[6 marks]

Question 5b

Extended tier only

Two cars are crash-tested, with crash test dummy 'drivers' wearing seatbelts, to assess the force reduction that crumple zones provide in a road-traffic accident.

Car **A** has a mass of 1200 kg and car **B** has a mass of 1500 kg.

Both cars have a driver of mass 70 kg and they **both** crash to a stop from an initial speed of 30 m/s.

At the moment of impact, the front ends of the cars crumple, taking different amounts of time to come to a stop. Car **A** takes 0.3 seconds to stop, while car **B** takes 0.7 seconds to stop.

Using this information, calculate the forces which would be experienced by the **cars** due to the impact.

(i) For car **A**

Force = ... N [3]

(ii) For car **B**

Force = ... N [2]

[5 marks]