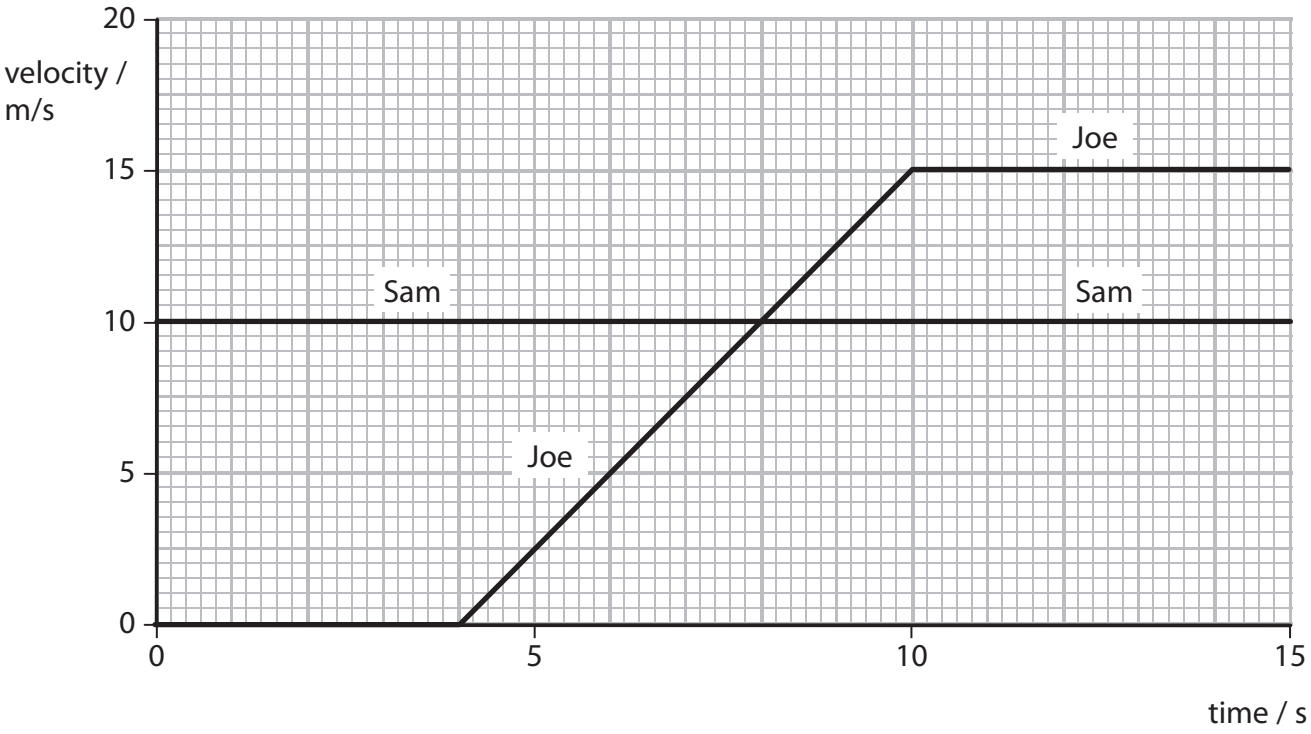
Motion and forces

1 Sam and Joe are on their bikes. They are on a flat, straight road.

(a) Joe is stationary when Sam rides past at a constant velocity of 10 m/s.

Joe waits for 4 s and then follows Sam.

This is a velocity/time graph of their motion.



(i) How far did Sam travel during these 15 s?

distance = velocity × time

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** 1.5 m

☒ **B** 10 m

☒ **C** 100 m

☒ **D** 150 m

(ii) At which of these times is the resultant force on Joe bigger than the resultant force on Sam?

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** at 3 s

☒ **B** at 7 s

☒ **C** at 11 s

☒ **D** at 15 s

(iii) For how many seconds was Joe accelerating?

(1)

number of seconds = ... s

(iv) Calculate Joe's acceleration during this time.

(2)

Joe's acceleration = ... m/s^2

(b) The diagram shows the horizontal forces acting on Joe at one point while he is accelerating.

(i) Calculate the size of the resultant horizontal force acting on Joe and his bike.

(2)

size of resultant force = ... N

(ii) The total mass of Joe, his heavy bag, and his bike is 55 kg.

Calculate the total weight.

Gravitational field strength, g = 10 N/kg

(1)

total weight = ... N

(c) On another day, Joe is riding the same bike on the same piece of road.

This time he does not have the heavy bag on his back.

He finds that it is easier to accelerate.

Explain why Joe finds it easier to accelerate.

(2)

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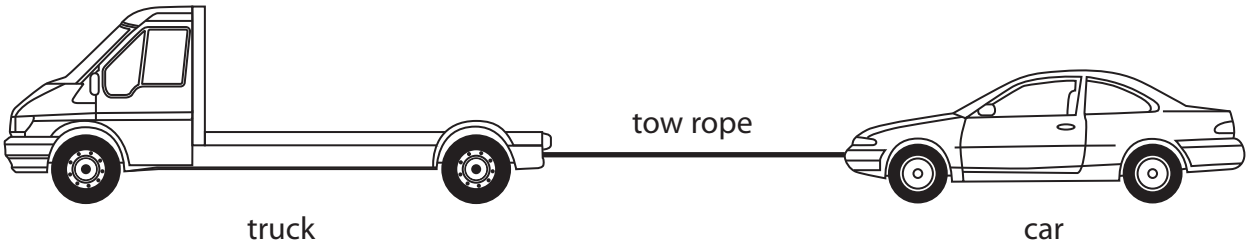
(Total for Question 4 = 10 marks)

2 A truck is towing a car along a level road at a constant velocity.

A tow rope is attached to the truck and the car.



(a) Which of these shows the directions of the forces between the car and the tow rope?

Put a cross (☒) in the box next to your answer.

(1)

	force exerted by car on tow rope	**force exerted by tow rope on car**
☒ **A**	←	→
☒ **B**	→	←
☒ **C**	→	→
☒ **D**	←	←

(b) The truck has to provide a force of 4000 N to the left on the car to keep the car at a constant velocity.

Complete the sentence by putting a cross (☒) in the box next to your answer.

The resultant force on the car is

(1)

☒ **A** 0 N

☒ **B** 4000 N to the left

☒ **C** 4000 N to the right

☒ **D** 8000 N to the left

(c) Both vehicles are travelling at 13 m/s.

The driver of the truck then accelerates at 1.2 m/s^2 until both vehicles are travelling at 20 m/s.

(i) Calculate the time taken for this acceleration.

(3)

time = ... s

(ii) The mass of the car is 1400 kg.

Calculate the resultant force on the car needed to produce an acceleration of 1.2 m/s^2.

(2)

force = ... N

(iii) A rope can withstand a tension of 12 000 N before it breaks.
The weight of the car is 14 000 N.

Discuss whether this rope could be strong enough to tow the car with the truck.

(3)

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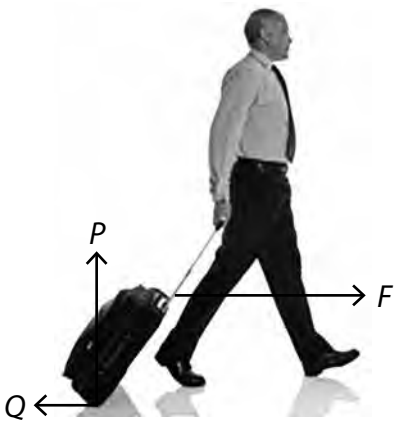
(Total for Question 4 = 10 marks)

3 A man pulls a suitcase with a horizontal force, *F*, as shown in Figure 10.

Two other forces acting on the suitcase are labelled *P* and *Q*.



Not to scale

Figure 10

(a) (i) Which of these gives the correct names for the forces *P* and *Q*?

(1)

		name of	
		force *P*	**force *Q***
☒	**A**	upthrust	reaction
☒	**B**	reaction	friction
☒	**C**	reaction	reaction
☒	**D**	friction	upthrust

(ii) Draw an arrow on the diagram to represent the weight of the suitcase.

(1)

(b) The man pulls the suitcase for 80 m along a horizontal path.

The mass of the man and the suitcase is 85 kg.

The man does 1200 J of work on the suitcase as he pulls the suitcase along.

He walks with an average velocity of 1.5 m / s.

(i) Calculate the kinetic energy of the man and the suitcase.

(2)

kinetic energy = ... J

(ii) Calculate the horizontal force, *F*, that the man exerts on the suitcase.

Use the equation:

work done = force $\times$ distance moved in the direction of the force

(2)

force = ... N

(c) The man runs up a set of stairs carrying his suitcase.

Explain whether he does more total work if he walks up the same stairs instead of running.

(2)

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(d) The man lifts his suitcase.

The increase in gravitational potential energy of the suitcase is 264 J.

The mass of the suitcase is 12 kg.

Calculate the vertical height the suitcase is raised.

(gravitational field strength, g = 10 N/kg)

Use the equation:

change in gravitational potential energy = mass $\times$ g $\times$ change in vertical height

(2)

height raised = ... m

(Total for Question 4 = 10 marks)