1. *(a)* Define *acceleration*.

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[1]

(b) (i) Two horizontal forces of 12 N and 8 N are applied to a toy car of mass 2·0 kg which is on a level surface. Calculate the maximum and minimum acceleration that could be experienced by the car.

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[3]

(ii) Sketch a free body diagram showing these forces when the car has minimum acceleration. [2]

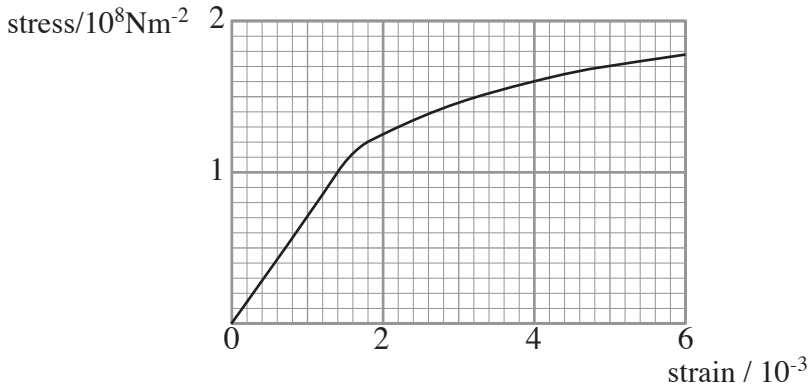
(c) At a later time, the following condition applies to the toy car:

$$\Sigma F = 0$$

Complete the table below, indicating with a tick in one column, whether each of the statements given 'must be true', 'could be true' or 'cannot be true' when the above condition applies. [4]

Statement	Must be true	Could be true	Cannot be true
The car is accelerating.			
The car is stationary.			
The car is moving at constant speed.			
There are no forces acting on the car			

2. Part of the graph of tensile stress against strain is plotted for an aluminium wire.



(a) (i) Explain why *strain* has no units.

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[1]

(ii) Label clearly on the graph the *limit of proportionality* [1]

(iii) Explain briefly what is meant by *inelastic (plastic)* stretching, and circle the region of the graph corresponding to inelastic stretching.

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[2]

(b) (i) Calculate from the graph a value for the Young modulus of aluminium.

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[3]

(ii) Calculate the force needed to produce a strain of $1{\cdot}0 \times 10^{-3}$ in an aluminum wire of cross-sectional area $5{\cdot}0 \times 10^{-7}$m^2.

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[3]

5. High-sided lorries are vulnerable to cross-winds when crossing motorway bridges. The force, F, exerted by wind on the side of a lorry can be given by

$$F = \rho A v^2$$

where ρ = density of air (kg m^{-3}), A = side area of the lorry and v = speed of the wind.

(a) (i) Show that the equation is correct in terms of units (or dimensions).

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[3]

(ii) The side of a certain lorry is (effectively) 15·0 m long and 4·2 m high. The force exerted on one side of the lorry by a cross-wind is $2{\cdot}8 \times 10^4$ N. Use this information to estimate the speed of the wind. (Density of air = 1·2 kg m^{-3}).

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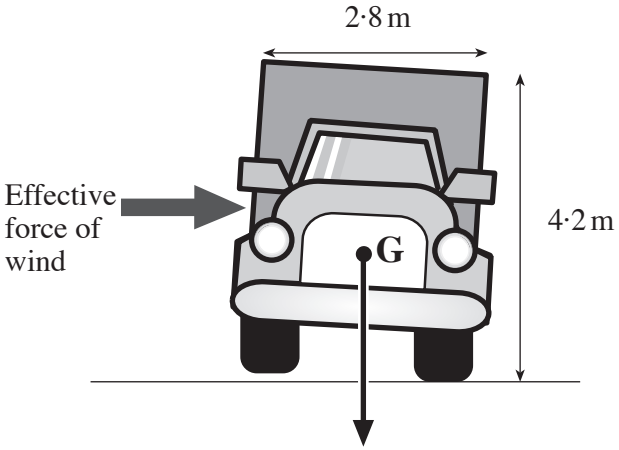
[2]

(b) When crossing a bridge, the lorry experiences a different cross-wind which causes it just to tilt as shown in the diagram.



(i) 'G' represents that point where the weight of the lorry is considered to act. Name this point.

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[1]

(ii) If the lorry stays tilted as shown, the sum of the clockwise moments about the pivot must equal the sum of the anticlockwise moments about the same pivot. Clearly label the pivot on the diagram.

[1]

(iii) Taking the force of the wind to act at a point **midway** up the side of the lorry, calculate the force needed to maintain the tilt as shown. The weight of the lorry is $1{\cdot}0 \times 10^5$ N and its width is 2·8 m.

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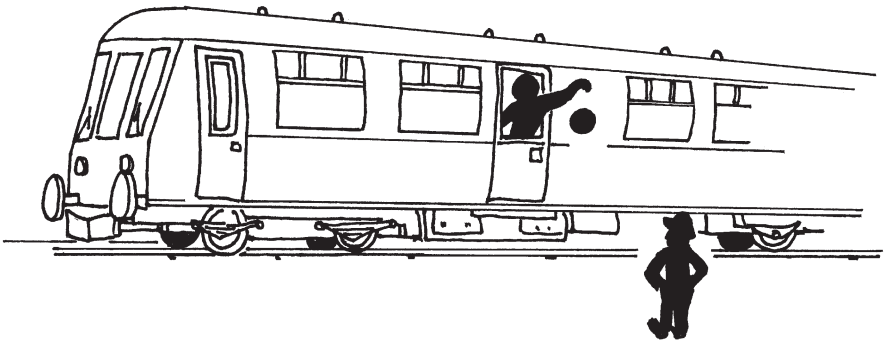
[3]

7. A passenger on a train, moving at a constant speed, drops a ball out of a window as shown. A stationary observer is standing near the track and directly in front of the window when the ball is dropped.



(a) (i) If air resistance is neglected, describe and explain the **horizontal** motion of the ball as seen by the passenger.

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[2]

(ii) Describe the horizontal motion of the ball as seen by the observer.

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[1]

(b) If air resistance is now taken into account, how will your answers to *(a)* (i) and (ii) have to be modified?

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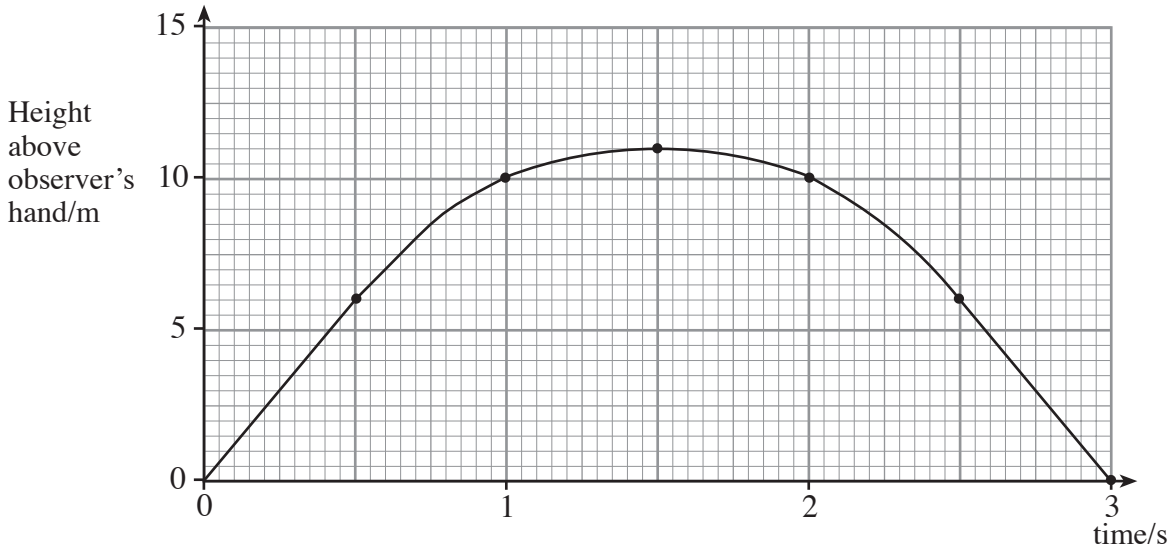
[3]

(c) The observer retrieves the ball and throws it vertically upwards, catching it on its return. A graph of height (from the observer's hand) against time is shown.



(i) How can you tell from the graph that the air resistance now acting on the ball is negligible?

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[1]

(ii) Explain why the mean velocity of the ball during the flight is $0\,ms^{-1}$.

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[3]

(iii) By considering the maximum height reached, determine the initial upward velocity of the ball.

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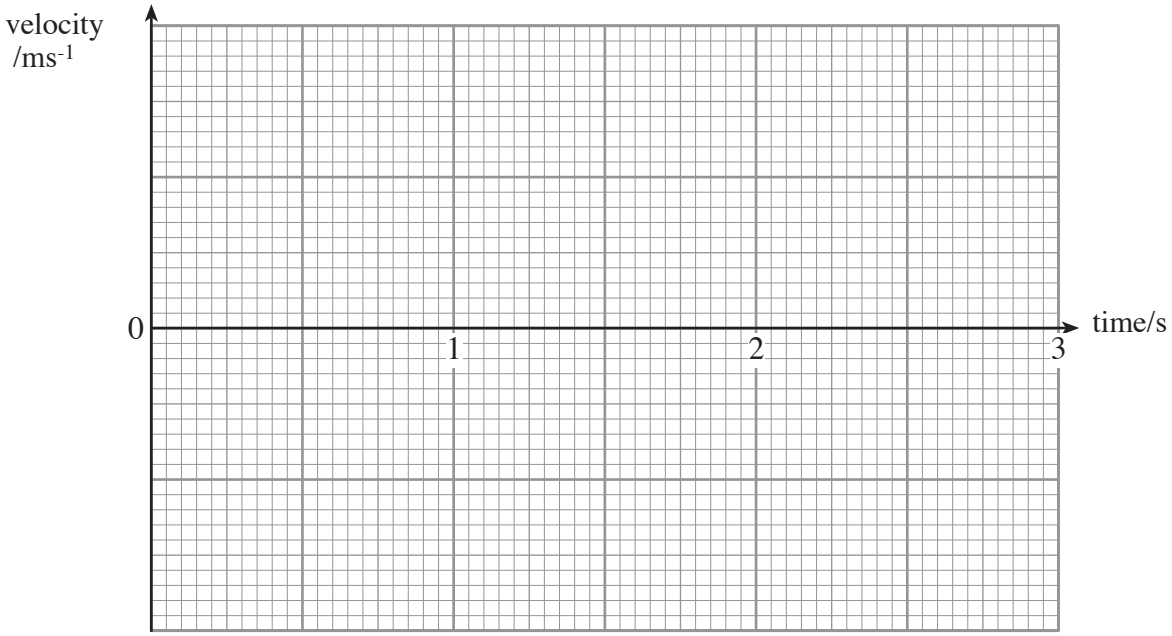
[3]

THE QUESTION CONTINUES ON THE NEXT PAGE

(iv) Use the answer to *(c)* (iii) and other data from the graph on the previous page to draw a velocity-time graph for the **whole** of the ball's flight. The time axis has been completed for you. [5]



(v) Use your velocity-time graph to verify the maximum height reached by the ball as shown on the height-time graph.

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[2]

RADIATION AND STARS

a) Calculate the radius of a star whose 650nm light creates an intensity of 20W per square metre at a distance of 2 parsecs. [7]
b) Define a blackbody and give an example. [3]
c) What is multi-wavelength astronomy and what can it tell us? [3]
d) What information can we gather from a spectrum from a distant star, and how do we accomplish this? [5]

PARTICLES & NUCLEAR STRUCTURE

a) What is a hadron? [2]
b) What is a baryon? [2]
c) How many generations of fundamental particles are there, and by what means did we discover them? [2]
d) Define each of the known interactions: gravitational, weak, electromagnetic and strong. State what each is experienced by, their range any other information you can provide. [12]