(50 marks)

*Answer **all** questions in this section in the spaces provided.*

22. (a) An experiment to investigate the drag force acting on an object at different speeds is carried out in a wind tunnel. The results are shown in the table below:

Speed v (m s^{-1})	Drag force D (N)	Speed squared v^2 (m^2 s^{-2})
4.04	169	
6.12	340	
7.99	512	
10.1	820	
11.9	1080	

   (i) Complete the table above by calculating each of the values of speed squared v^2 to the appropriate number of significant figures. (3 marks)

   (ii) On the page opposite, plot (*in pencil*) a graph of drag force D against speed squared v^2 and draw a line of best fit. (4 marks)

   (iii) State and explain whether your graph is consistent with the hypothesis that the drag force is directly proportional to the speed squared ($D \propto v^2$).

   _____

   _____

   _____

   _____

   _____

   _____ (3 marks)

(b) The experiment is repeated, using a different-shaped object. The graph obtained from the results of this second experiment is shown below:

speed squared v^2 (m² s⁻²)
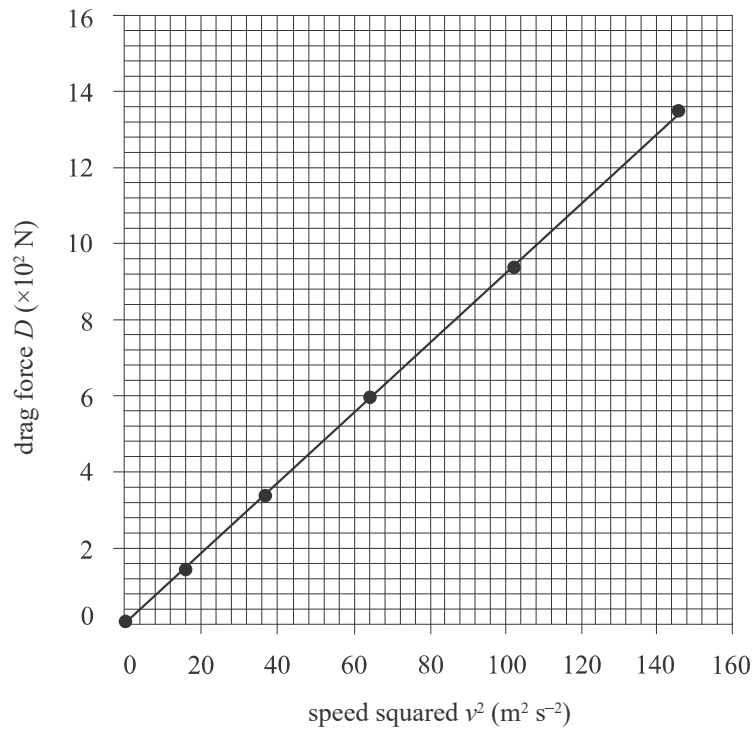
(i) Using the graph above, determine the drag force that would be produced if $v^2 = 155$ m² s⁻². Clearly indicate on your graph how you arrived at your answer.

_____

_____ (2 marks)

(ii) Calculate the gradient of the line of best fit for this graph, clearly labelling on the graph the points you have used. State the units of the gradient.

_____

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_____

_____

_____

_____ (3 marks)

4

(iii) The relationship between the drag force and the speed of the object is given by

$$D = \frac{1}{2}\rho v^2 A C$$

where ρ is the density of the surrounding fluid, A is the cross-sectional area of the object, and C is the drag coefficient of the object (it has no units).

Using this relationship and the gradient you calculated in part (b)(ii), find the value of the drag coefficient C for this experiment if $\rho = 1.23$ kg m^{-3} and $A = 0.25$ m^2.

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_____ (3 marks)

(c) State and explain the type of error in your graph in part (a), given the relationship described in part (b)(iii).

_____

_____

_____

_____ (2 marks)

(d) Identify *two* factors that should be held constant during an experiment to investigate the drag force acting on an object at different speeds.

_____

_____

_____

_____ (2 marks)