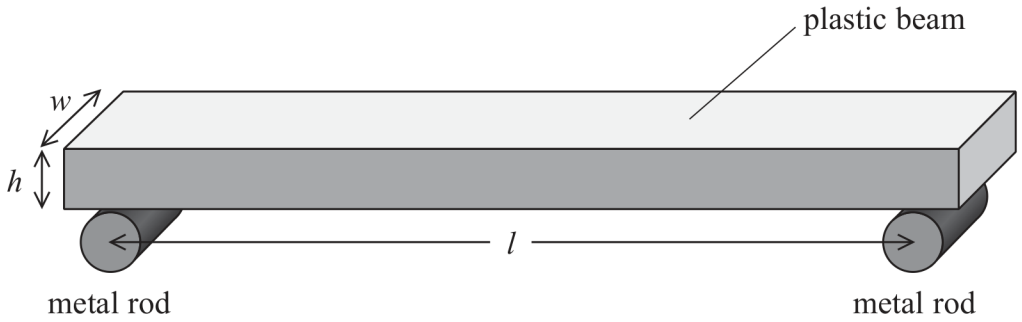
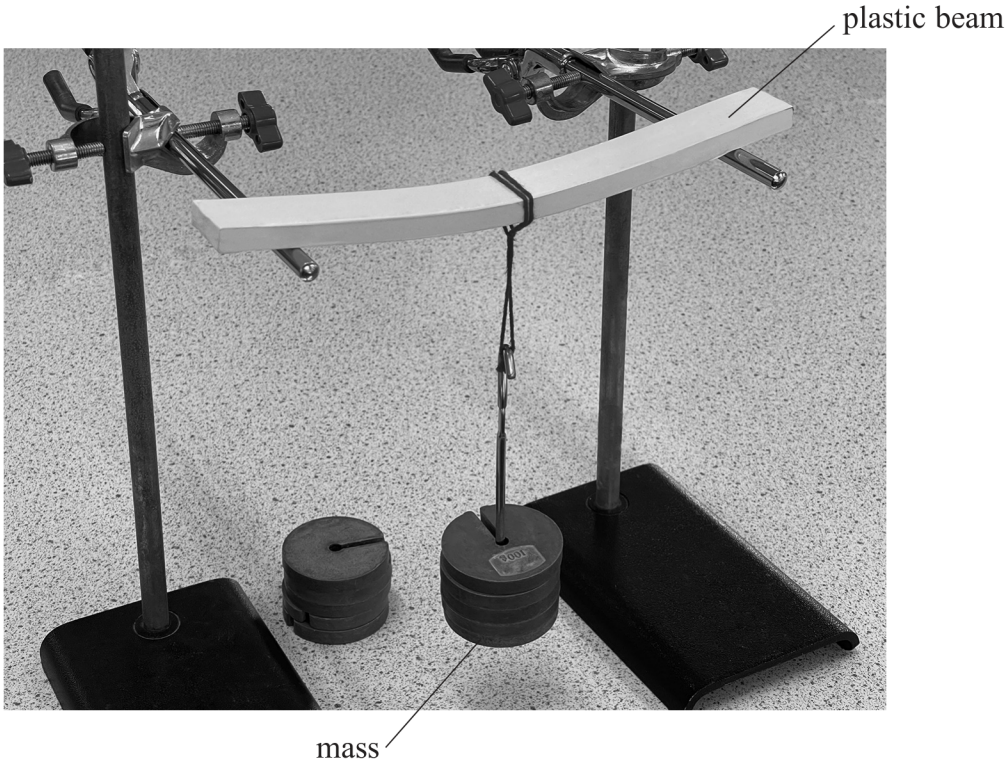
4 A student investigated the bending of a plastic beam.

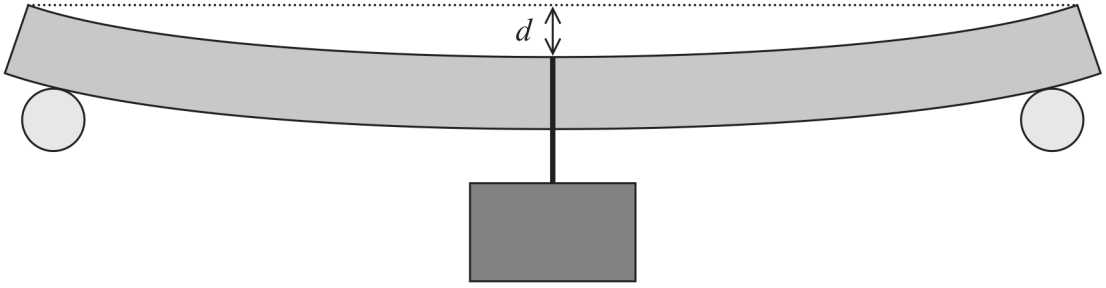
The beam, of width w and height h, was supported at either end by two metal rods a distance l apart, as shown.



She applied a force F to the middle of the plastic beam by hanging a mass from it.



The beam bent downwards as shown.



She measured the vertical distance d moved by the middle of the plastic beam and repeated this measurement for increasing values of F.

She recorded her results in a table, as shown.

F / N	d / m
4.9	0.0007
9.8	0.0013
14.7	0.002
19.6	0.0027
24.5	0.0033
29.4	0.004

(a) Criticise the recording of these results.

(2)

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(b) Using the grid opposite, plot a graph of d on the y-axis against F on the x-axis.

(5)

(c) (i) The 'bending modulus' E of the plastic beam can be calculated using the equation

$$E = \frac{l^3 F}{4wh^3 d}$$

Show that the gradient of the graph is equal to $\frac{l^3}{4wh^3 E}$

(2)

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(ii) Determine the gradient of your graph.

(2)

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Gradient = ...

(iii) The student recorded the following measurements for the plastic beam.

l / cm	30
w / mm	20
h / mm	10

Determine E, in GPa, for the plastic beam.

(2)

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E = ... GPa

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(d) The student's teacher suggested that using a plastic beam with a smaller value of h would improve the measurement of d.

Justify the teacher's statement.

(2)

(e) The student suggested repeating the investigation using a glass rod instead of a plastic beam.

Explain a safety issue that would be caused by using a glass rod.

(2)

(Total for Question 4 = 17 marks)