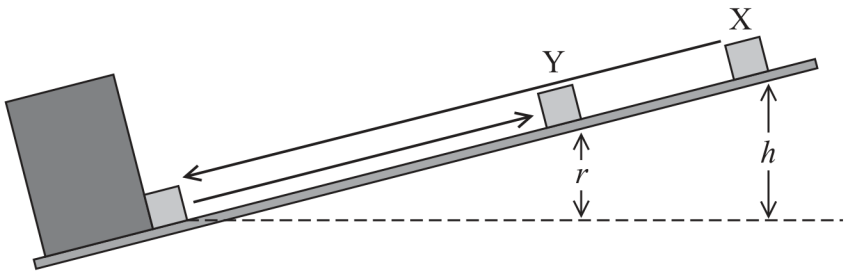
4 A student slid a small metal cube down a frictionless ramp. The cube collided with a fixed metal block at the bottom of the ramp.

The student released the cube from position X as shown in the diagram. After the collision, the cube rebounded to position Y.



The student measured heights h and r. He then repeated the experiment using several different starting positions.

(a) The student recorded his results in the table below.

h / m	r / m
0.20	0.11
0.25	0.137
0.30	0.16
0.35	0.19
0.40	0.217
0.45	0.24

(i) Criticise these results.

(2)

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(ii) Plot a graph of r on the y-axis and h on the x-axis.

(5)

(b) (i) Show that the velocity u of the cube immediately before the collision is given by

$$u = \sqrt{2gh}$$

(2)

(ii) The coefficient of restitution e is given by the equation

$$e = \frac{v}{u}$$

where v is the velocity of the cube immediately after the collision.

Explain why the gradient of the graph is e^2.

(3)

(c) The student researched the range of values for the coefficients of restitution e of different metals.

stainless steel	$0.63 < e < 0.93$
cast iron	$0.3 < e < 0.6$

Determine which of these metals the cube could be made from.

(3)

(d) Explain how friction between the cube and the surface of the ramp would affect the value obtained for e.

(2)

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(Total for Question 4 = 17 marks)