Past-paper walk-through

Pressure ▪ 8.2

eXercise

Questions in this set

- 2021 Q2

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 2

2021 ▪ Q2

(12 points, suggested time 25 minutes)
A group of students is investigating how the thickness of a plastic rod affects the maximum force F_{max} with which the rod can be pulled without breaking. Two students are discussing models to represent how F_{max} depends on rod thickness.
Student A claims that F_{max} is directly proportional to the radius of the rod.
Student B claims that F_{max} is directly proportional to the cross-sectional area of the rod—the area of the base of the cylinder, shaded gray in the figure above.
[Figure: A cylindrical rod shown lengthwise, with one circular end face shaded gray to indicate the cross-sectional area.]

Question 2

(a) The students have a collection of many rods of the same material. The rods are all the same length but come in a range of six different thicknesses. Design an experimental procedure to determine which student's model, if either, correctly represents how $F_{\max}$ depends on rod thickness.
In the table below, list the quantities that would be measured in your experiment. Define a symbol to represent each quantity, and also list the equipment that would be used to measure each quantity. You do not need to fill in every row. If you need additional rows, you may add them to the space just below the table.

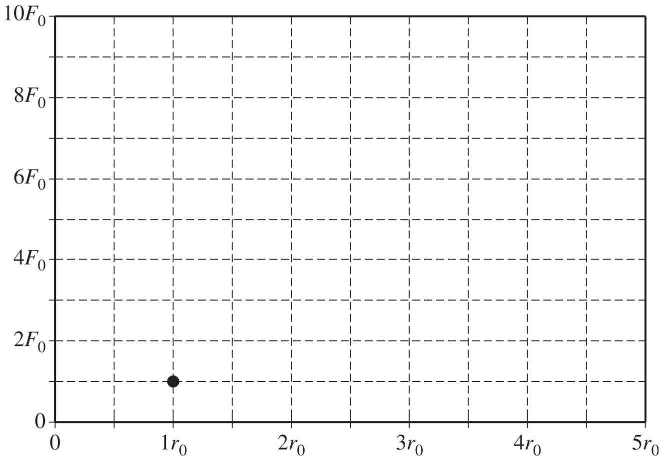
Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

Question 2

Describe the overall procedure to be used, referring to the table. Provide enough detail so that another student could replicate the experiment, including any steps necessary to reduce experimental uncertainty. As needed, use the symbols defined in the table and/or include a simple diagram of the setup.

Question 2

Question 2



Question 2

2021 ▪ Q2

(12 points, suggested time 25 minutes)

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Student B claims that F_{max} is directly proportional to the cross-sectional area of the rod—the area of the base of the cylinder, shaded gray in the figure above.

[Figure: A cylindrical rod shown lengthwise, with one circular end face shaded gray to indicate the cross-sectional area.]

(b) For a rod of radius r_0, it is determined that F_{max} is F_0, as indicated by the dot on the grid below. On the grid, draw and label graphs corresponding to the two students'

Question 2

models of the dependence of $F_{\max}$ on rod radius. Clearly label each graph "A" or "B," corresponding to the appropriate model.
[Graph grid: vertical axis labeled with gridlines at $2F_0, 4F_0, 6F_0, 8F_0, 10F_0$ (origin 0); horizontal axis labeled with gridlines at $1r_0, 2r_0, 3r_0, 4r_0, 5r_0$ (origin 0); a single data point plotted at $(1r_0, F_0)$.]

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[Figure: A cylindrical rod shown lengthwise, with one circular end face shaded gray to indicate the cross-sectional area.]

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(c) The table below shows results of measurements taken by another group of students for rods of different thicknesses.

Rod radius (mm)	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
F_{max} (N)	40	120	320	520	900

On the grid below, plot the data points from the table. Clearly scale and label all axes, including units. Draw either a straight line or a curve that best represents the data.

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[Graph: large blank grid (approximately 20 columns by 18 rows of gridlines) for the student to scale, label, plot the five data points, and draw a best-fit line/curve.]

Question 2

2021 ▪ Q2

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[Figure: A cylindrical rod shown lengthwise, with one circular end face shaded gray to indicate the cross-sectional area.]

(d) Which student's model is more closely represented by the evidence shown in the graph you drew in part (c)?

______ Student A's model: $F_{\max}$ is directly proportional to the radius of the rod.

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______ Student B's model: $F_{\max}$ is directly proportional to the cross-sectional area of the rod.
Explain your reasoning.

Solution 2

(a) Mark scheme

- Example procedure: Measure the diameter (or radius) D of each rod with a ruler/caliper. Pull on the rod with a force probe until it breaks, recording the force $F_{\max}$ just before breaking. Repeat each trial several times (and average) to reduce experimental uncertainty from the breaking process, then repeat for rods of each different radius. Points: (1) measuring radius/diameter with an appropriate tool, (2) measuring force with an appropriate tool (e.g. force probe/spring scale), (3) a plausible/practical way to determine $F_{\max}$ for a given rod, (4) an attempt to reduce experimental uncertainty (e.g. repeated trials/averaging) given that breaking the rods is a destructive, one-shot measurement.

Solution 2

(b)

Mark scheme

- Draw two curves that both pass through the given point (r_0, F_0). Model A (linear, $F_{\max} \propto r$): a straight line through the origin with slope F_0/r_0. Model B (quadratic, $F_{\max} \propto r^2$): a concave-up curve through the origin that also passes through (r_0, F_0), lying below line A for $r < r_0$ and rising above line A for $r > r_0$ (e.g. reaching about $4F_0$ near $2r_0$). Points: (1) straight line 'A' with slope F_0/r_0, (2) curve 'B' concave up, (3) curve 'B' showing a quadratic relationship at the correct points, (4) both graphs passing through (r_0, F_0).

Solution 2

(c)

Mark scheme

- Plot the five data points (radius in mm, $F_{\max}$ in N): $(0.5, 40)$, $(1.0, 120)$, $(1.5, 320)$, $(2.0, 520)$, $(2.5, 900)$ on linear axes labeled with units (radius 0-3 mm, $F_{\max}$ 0-1000 N), scaled so the data fill at least half the grid's width and height, then draw a smooth best-fit curve through the points (concave up, consistent with a quadratic trend). Points: (1) linear scales with appropriate labels/units and data spanning at least half the grid, (2) correctly plotting the points, (3) a reasonable best-fit curve.

Solution 2

(d)

Mark scheme

- Model B is supported by the data: $F_{\max}$ increases as the square of the rod radius (i.e. $F_{\max} \propto r^2$), consistent with the concave-up curve in part (c). (Equivalently, plotting $F_{\max}$ vs. r^2 would yield a straight line.)