

Question 2: Experimental Design**12 points**

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| (a) | For measuring the radius or diameter of rods with different radii using an appropriate tool | 1 point |
| | For measuring force using an appropriate tool | 1 point |
| | For a plausible/practical way to directly or indirectly determine $F_{\max}$ for a given rod | 1 point |
| | For attempting to reduce experimental uncertainty in an experiment that involves breaking the rods | 1 point |

Example response for part (a)

Measure the diameter D of each rod with a ruler.

Students should pull on the rod with the force probe until the rod breaks.

Record the force $F_{\max}$ just before breaking.

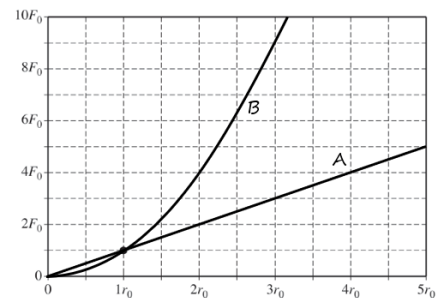
Repeat each trial several times to reduce error.

Then trade for a new set of rods with different radii.

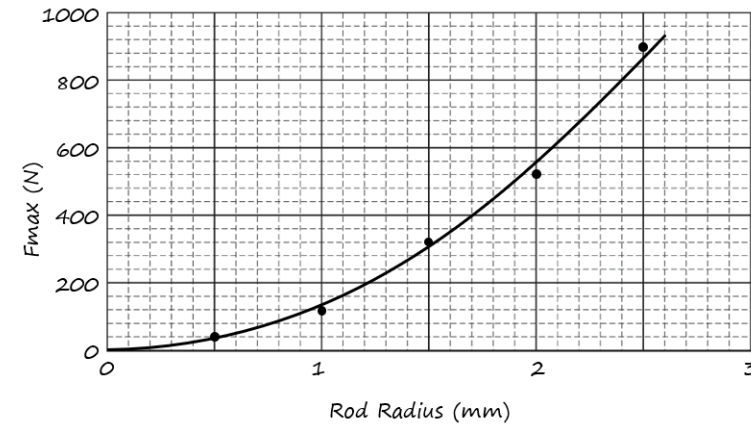
Repeat this experiment for several different radii rods.

Total for part (a) 4 points

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| (b) | For a straight-line graph marked "A" with a slope of $\frac{F_0}{r_0}$ | 1 point |
| | For a graph marked "B" that is concave up | 1 point |
| | For a graph marked "B" that shows a quadratic relationship at the correct points | 1 point |
| | For two graphs that both contain the point (r_0, F_0) | 1 point |

Example response for part (b)**Total for part (b) 4 points**

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| (c) | For linear scales with appropriate labels and units | 1 point |
| | AND | |
| | for a graph where the plotted points cover at least half of the grid's width and height | |
| | For plotting the points correctly | 1 point |
| | For drawing a reasonable best-fit curve | 1 point |

Example response for part (c)**Total for part (c) 3 points**

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| (d) | For identifying Model B and for indicating that $F_{\max}$ increases as the square of the radius increases | 1 point |
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Example response for part (d)

In this graph, $F_{\max}$ seems to be proportional to R^2 , so that if we graph $F_{\max}$ on the vertical axis and R^2 on the horizontal axis, it should show a linear graph.

Total for question 2 12 points