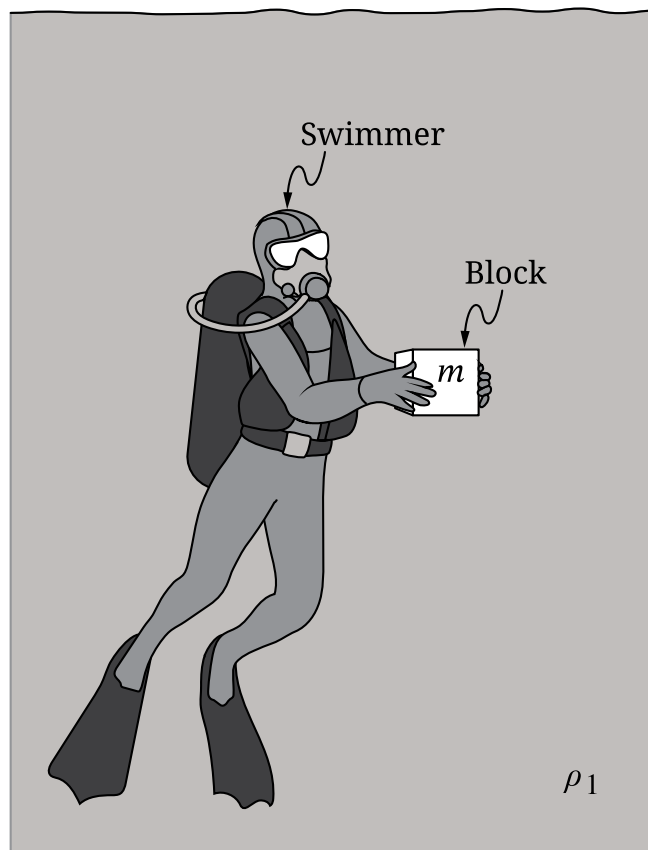


Question 4

4. In Scenario 1, a swimmer holds a block of mass m at rest in a tank of freshwater with density ρ_1 , as shown in Figure 1. The block is released from rest and accelerates upward with an initial acceleration a_1 . All frictional forces are negligible.

Figure 1

In Scenario 2, the swimmer holds the same block at rest in a tank of salt water with density ρ_2 , where $\rho_2 > \rho_1$. The swimmer again releases the block from rest, and the block accelerates upward with initial acceleration a_2 . All frictional forces are negligible.

A. **Indicate** whether a_1 is greater than, less than, or equal to a_2 by writing one of the following in your answer booklet.

- $a_1 > a_2$
- $a_1 < a_2$
- $a_1 = a_2$

Justify your answer in terms of ALL forces exerted on the block in each scenario. Use qualitative reasoning beyond referencing equations.

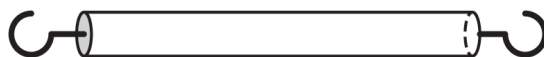
B. Consider the general case where a block of mass m and volume V is completely submerged in a fluid of density ρ .

Starting with Newton's second law, **derive** an expression for the initial upward acceleration a of the block when the block is released from rest. Express your answer in terms of m , V , ρ , and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

C. **Indicate** whether the expression for the acceleration a you derived in part B is or is not consistent with the claim made in part A. Briefly **justify** your answer by referencing your derivation in part B.

STOP

END OF EXAM



(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.

(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.

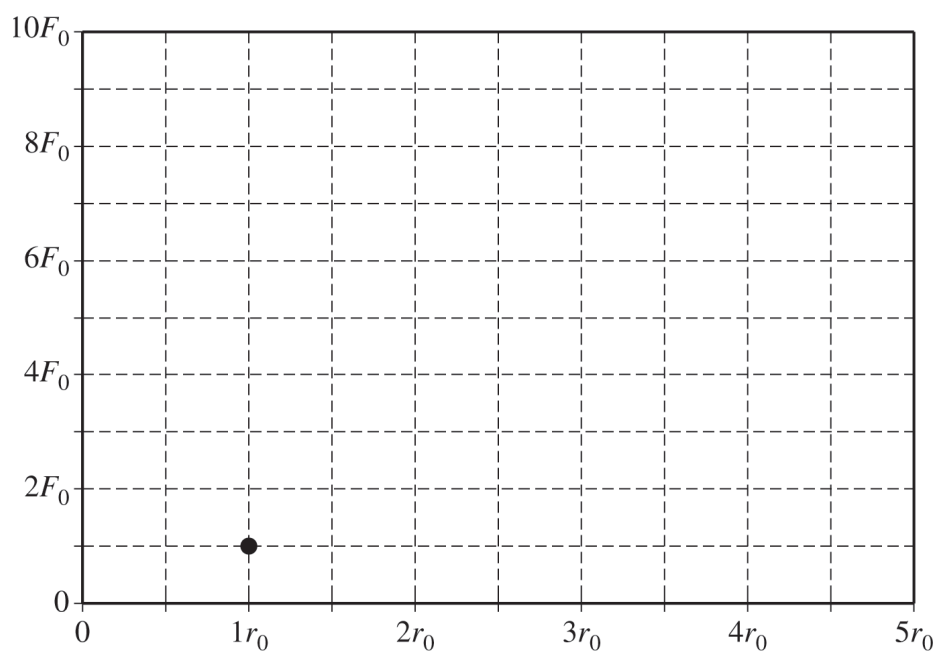
Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

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Use a pencil or pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

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.

(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' models of the dependence of $F_{\max}$ on rod radius. Clearly label each graph "A" or "B," corresponding to the appropriate model.



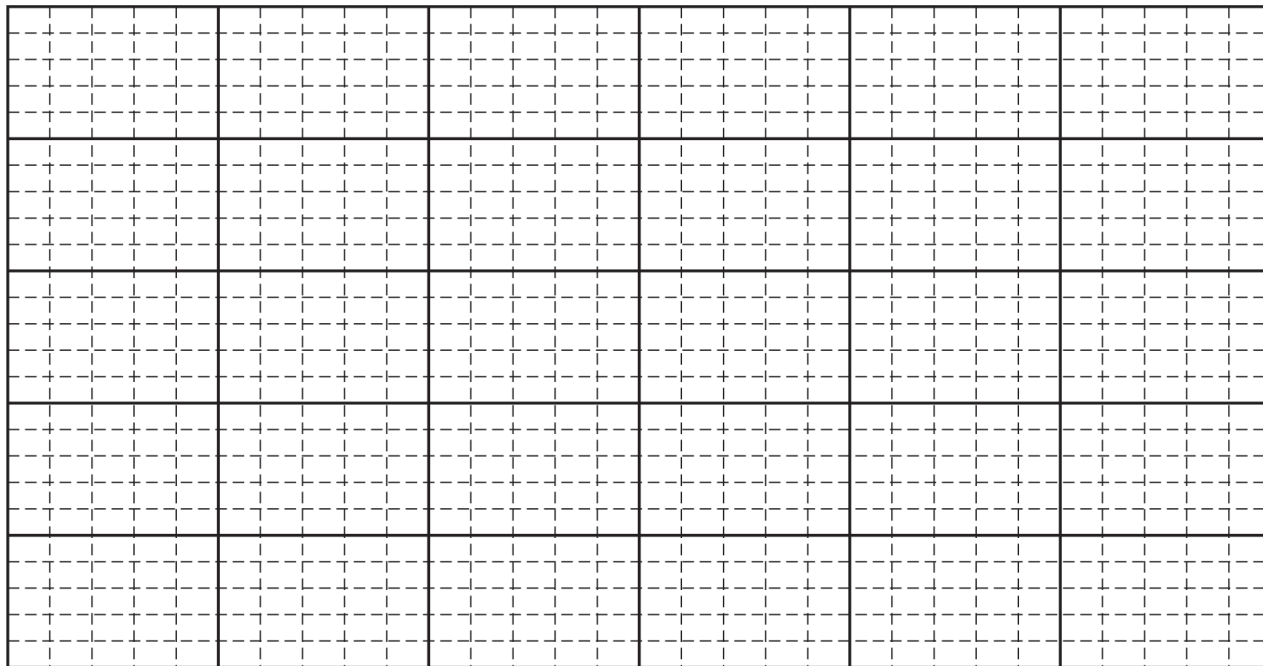
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Use a pencil or pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

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

(c) 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.



(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.

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

Explain your reasoning.

GO ON TO THE NEXT PAGE.

Use a pencil or pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

2. (12 points, suggested time 25 minutes)

A group of students prepare a large batch of conductive dough (a soft substance that can conduct electricity) and then mold the dough into several cylinders with various cross-sectional areas A and lengths ℓ . Each student applies a potential difference ΔV across the ends of a dough cylinder and determines the resistance R of the cylinder. The results of their experiments are shown in the table below.

Dough Cylinder	A (m^2)	ℓ (m)	ΔV (V)	R (Ω)		
1	0.00049	0.030	1.02	23.6		
2	0.00049	0.050	2.34	31.5		
3	0.00053	0.080	3.58	61.2		
4	0.00057	0.150	6.21	105		

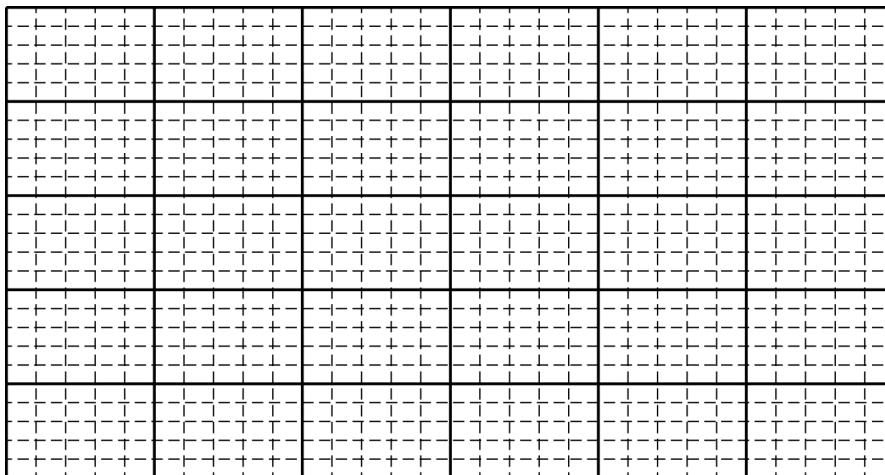
(a) The students want to determine the resistivity of the dough cylinders.

- i. Indicate below which quantities could be graphed to determine a value for the resistivity of the dough cylinders. You may use the remaining columns in the table above, as needed, to record any quantities (including units) that are not already in the table.

Vertical Axis: _____

Horizontal Axis: _____

- ii. On the grid below, plot the appropriate quantities to determine the resistivity of the dough cylinders. Clearly scale and label all axes, including units as appropriate.



- iii. Use the above graph to estimate a value for the resistivity of the dough cylinders.

- (b) Another group of students perform the experiment described in part (a) but shape the dough into long rectangular shapes instead of cylinders. Will this change affect the value of the resistivity determined by the second group of students?

____ Yes ____ No

Briefly justify your reasoning.

- (c) Describe an experimental procedure to determine whether or not the resistivity of the dough cylinders depends on the temperature of the dough. Give enough detail so that another student could replicate the experiment. As needed, include a diagram of the experimental setup. Assume equipment usually found in a school physics laboratory is available.