Instructions for teachers:

This option is for teachers and students who feel the current ACT science is too fast for comfort. This option allows the students and teacher to break down the figures, examine more carefully what the variables are in each graph, what is being studied, and how everything is measured.

The document is 2 pages, so you can photocopy the document front-to-back and have students keep this paper for the entire week.

The suggestion is the spend days 1 and 2 on the open-ended questions examining the graphs, and then starting the multiple-choice questions either part-way on day 2, or on day 3.

It is more important that some discussion takes place about the tables rather than rushing through the answers to the questions.

Any feedback on Science ACT practice is appreciated to the science team. Send e-mails to Victor Chen.

DAYS 1-2 of ACT Week

PASSAGE VII

It is well known that applying a force to both ends of a bar will cause the bar to compress or to expand, depending on whether the force pushes or pulls the bar. The *stress* on the bar is defined to be the ratio of the force on the bar to the cross-sectional area, and the *strain* on the bar is the fractional change in length. As long as the force is not too strong, stress is directly proportional to strain, and the constant of proportionality is called *Young's modulus*. If the force on the bar exceeds the yield strength of the material, however, permanent deformation will occur, and the bar will not resume its original shape upon removal of the force. In the experiments below, a scientist investigated these properties.

Experiment 1

Aluminum has a Young's modulus of 70×10^9 newtons per square meter (N/m^2). Using a 2-meter-long bar of cross-sectional area 1 square meter (m^2), a scientist applied different forces to the bar and noted the various changes in length. The bar returned to its original shape after the forces were removed in all trials except the final one. The results are shown in Table 1.

Table 1

Applied Force (10^6 N)	Change in Length (mm)
50	1.4
100	2.8
200	5.6
400	11.2

Experiment 2

The effect of length expansion or compression can be seen in many materials. The scientist performed another experiment in order to determine to what extent a bar made out of each of the materials tested would stretch. The bars under consideration were each 2 meters long with a cross-sectional area of 1 m^2, and compressive forces of 100×10^6 N were applied to each end before the data was recorded. The results are shown in Table 2.

Table 2

Material	Young's Modulus (10^9 N/m^2)	Change in Length (mm)
Steel	200	1.0
Concrete	30	6.6
Wood	13	15.4
Polystyrene	2	66.7

Experiment 3

Finally, the scientist investigated how different aluminum bars stretched when a force of 100×10^6 N was applied to both ends of the bars. The results are shown in Table 3.

Table 3

Length of Bar (m)	Cross-Sectional Area (m^2)	Change in Length (mm)
1.0	2.0	0.7
1.0	4.0	0.4
1.0	8.0	0.2
2.0	2.0	1.4
4.0	2.0	2.8
8.0	4.0	2.8
16.0	4.0	5.6

In the ACT Science Section, you will see three "Experiments" passages. They are easy to spot. They usually contain an introductory paragraph followed by a number of experiments and six questions.

1. The first thing you need to do in an Experiments passage is to identify the ***objective***. The objective is a statement that tells you the purpose of the study (*what* they are studying). The objective is usually found in the beginning or the end of the introductory paragraph. Once you find it, underline the objective.

2. The second thing you need to do is to follow the procedure of each experiment and identify the variables. Then, jot down a few words along side each of the experiments to make a note of what is changing in each case.

3. The final thing you need to do in an Experiments section is to study the results. The results are the conclusion of the study. When you study the results, make sure you underline them or write some notes in the margin. Once you've finished this step, look for any patterns, and move on to the questions.

Instructions: In the Science ACT, you will see three "Experiments" passages where the results from different experiments will be presented. Skim through the opening paragraphs to get the basic idea of what is being tested. Then, after reading each experiment, jot some quick notes about what is being tested, what was the testing condition, and brief results.

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1. According to the data in the experiments, when both the length and cross-sectional area of an aluminum bar are doubled, the change in length:
A. quadruples B. doubles
C. remains the same D. halves

2. Yield strength is the greatest force that a material can withstand without changing shape permanently. Based on Experiment 1, one can conclude that the yield strength of aluminum is approximately:
F. 75×10^6 N. G. 125×10^6 N.
H. 175×10^6 N. J. 300×10^6 N

3. The Young's modulus of glass is 65×10^9 N/m$_2$. A 2-meter-long glass bar with a cross-sectional area of 1 m2 with a force of 100×10^6 N applied to both ends would experience a change in length of:
A. 3.2 millimeters. B. 7.3 millimeters
C. 30.8 millimeters. D. 133.4 millimeters

4. Given the results of the experiments, all of the following would be expected to increase the change in the length of a bar EXCEPT:
F. increasing the applied force.
G. increasing the cross-sectional area.
H. increasing the length of the bar.
J. decreasing the Young's modulus.

5. The scientist suspected that the temperature of the bar may have an effect on the change in length. Which of the following, if true, would best support that hypothesis?
A. As the temperature of a material changes, so does its Young's modulus.
B. As the temperature of a material changes, the material becomes less dense.
C. The Young's modulus of a given material is independent of temperature
D. The Young's modulus of steel is greater than that of aluminum.

6. Based on the data in the passage, if a force of 100×10^6 N were applied to an aluminum bar 32 meters long with a cross-sectional area of 4.0 m^2, the change in the length of the bar would most nearly be:
F. 1.4 millimeters. G. 2.8 millimeters.
H. 11.2 millimeters. J. 22.4 millimeters

Now, on to what it asks students to do (annotating)

- Objective (in short): Investigate mechanical properties of different materials. It's not necessary to fully understand all the terminology about stress, strain, Young's modulus, force, etc. Just as long as you get the main idea that these are properties of the materials, and applying a force on them you can measure these properties.
- Experiment 1: You're measuring a 2 meter bar of aluminum. It's Young's modulus is constant at 70×10^9 N/m^2. Forces were applied and the changes in length were measured. The bar returned to its original shape every time except in the last trial.
- Experiment 2: Different materials with different Young's moduli were compressed with a constant force and the changes in length were measured.
- Experiment 3: Aluminum bars of different sizes were stretched with a constant force and the changes in length were measured.

MC Answers

1. The best answer is C. If we looked at Table 3, and find the entry where the length is equal to 4.0 and the cross-sectional area is equal to 2.0, we see that the change in length is 2.8. If both the length and cross-sectional area are doubled, such that the length is 8.0 and the cross-sectional area is 4.0, the change in length remains 2.8. The change in length has stayed the same so the answer is C.

2. The best answer is J. The passage tells us that *if the force on the bar exceeds the yield strength…permanent deformation will occur, and the bar will not resume its original shape.* Under Experiment 1, we see that the aluminum returned to its original shape in all trials except in the final one. This means that the yield strength is not as great as 400 but greater than 200.

3. The best answer is A. According to Table 2, we see that the Young's modulus of glass will fall somewhere between the Young's modulus of concrete (which is 30×10^9 N/m^2) and that of steel (which is 200×10^9 N/m^2). This means that the change in length should be somewhere between that of concrete (6.6) and that of steel (1.0). The only answer choice in this range is A.

4. The best answer is G. From Table 1, we can see that if the applied force increases, so does the change in length. This allows us to eliminate (F). In Table 2, we can see that decreasing the Young's modulus is associated with an increase in the change in length. This allows us to eliminate (J). If we look at the fourth and fifth rows of Table 3, we find a case where the cross-sectional area remains constant but the length of the bar increases. The change in length also increases, so this must be due to the increasing length of the bar. Therefore, we can eliminate (H). We can see from the first two rows of Table 3 that increasing cross-sectional area does not increase the change in length; instead, the change in length decreases from 0.7 to 0.4. This makes (G) the answer.

5. The best answer is A. We don't know anything about density, so (B) is out. Choice (C) actually hurts the hypothesis, as it says that temperature would not affect the Young's modulus, which we does know have an effect on the change in length. Finally, while (D) is a true statement, it would not help the hypothesis that temperature would affect change in length. Therefore, the best answer is (A).

6. The best answer is H. We can tell from Table 3 that a bar 16 meters long with a 4 meter square cross-section would change about 5.6 millimeters, and that this is double the change from a bar with the same cross-section and half the length. We can, therefore, infer that if we double the length to 32 meters and keep the same cross-section, the bar will change about twice as much, or about 11 millimeters. This makes (H) the best answer.