This diagnostic test consists of two parts, Fundamentals and Problem Solving. If your student can solve nearly all of the Fundamentals problems and at least half of the Problem Solving problems, then the student is ready for the Art of Problem Solving Online Class **Scholars High School Physics: Foundations**.

If the student cannot solve more than 80% of the Fundamentals section, or has a great deal of difficulty with the Problem Solving section, then the student should consider our **Math 7 (Part 1)** course. This course will both teach the skills used on this test and help students develop their problem-solving skills.

In places, the numbers on this test are not selected to simplify the problem and are not whole numbers. This reflects how, in physics, we often work with numbers derived from experiment, not specially chosen examples. To help with the computations, students are allowed a calculator on this test, and will use calculators extensively in the class. Any calculator is fine.

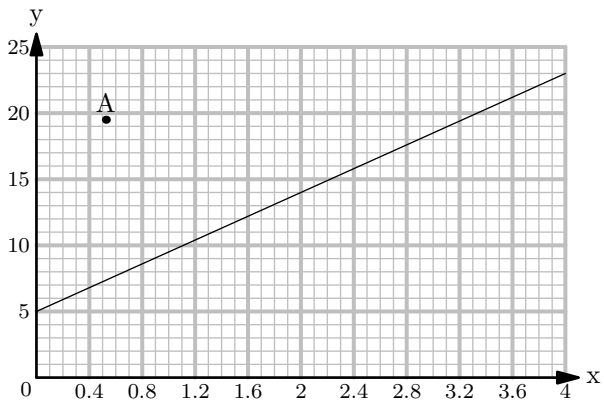
We recommend using the following process in administering this diagnostic:

> Step 1: The student should attempt all of the questions below without any help. **A calculator is allowed.** There is no time limit.
> Step 2: Check the student's responses using the answer key at the end of this document.
> Step 3: The student should be given a second chance on the problems that they answered incorrectly (except for Problem 11.)

Fundamentals

1. **Computational Skills** Evaluate each of the following:
   (a) $\dfrac{(1.23)^2-(0.75)(0.15)}{0.83}$, rounded to the nearest hundredth.
   (b) 85.2% of 1200, rounded up to the next integer.
   (c) $4\left[\dfrac{2}{3}(10)\left(\dfrac{1}{4}\right)^3\right]$, expressed as a simplified fraction.
   (d) $\left[\sqrt{5}\left(\dfrac{8}{25}\right)^{\frac{1}{3}}\right]^6-\frac{2}{5}$, expressed as a simplified fraction.
2. **Algebra Skills**.
   (a) Solve for x: $0.23x+5.7-1.11x=\frac{2.12x-0.4}{(0.25)^2}$. Report your answer to the nearest thousandth.
   (b) Solve for a and b: $3a=2-4b$ and $b=5a-11$.
   (c) If $v=\sqrt{\dfrac{2mg}{apc}}$, solve for p in terms of the other variables.

3. **Working with Graphs**. Using the graph below, identify each of the following:



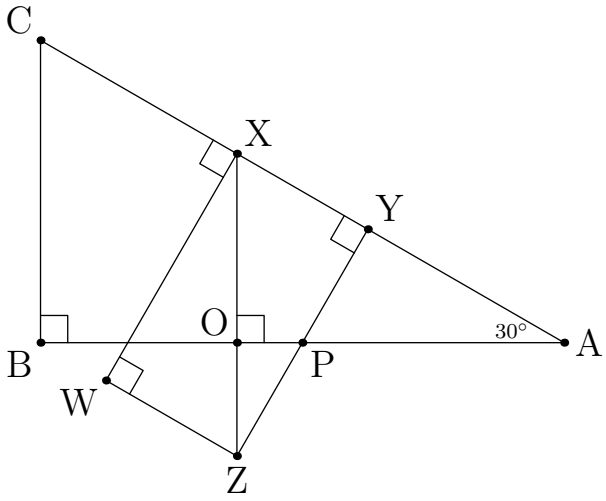
   (a) The coordinates of the point A.

   (b) The slope of the line.

   (c) The equation of the line.

4. There are 100 centimeters in one meter, and there are 1000 meters in one kilometer. How many centimeters are there in 30 kilometers?

5. **Angles**. In the diagram below, determine each of the following:



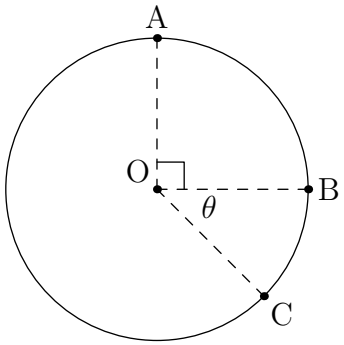
   (a) $\angle BCA$.

   (b) $\angle OPZ$.

   (c) $\angle WXZ$.

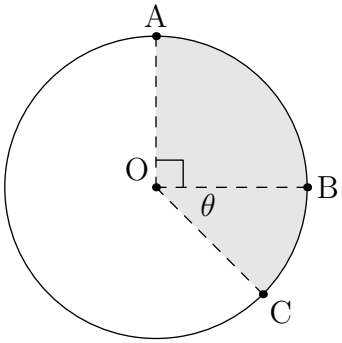
   (d) $\angle WZX$.

6. **Circles**. The circle shown below has radius $r = 2$. Point O is the center of the circle and points $A, B,$ and C lie on the circle. Compute the following:



(a) The length of arc AB.

(b) The area of sector $A - O - C$ when $\theta = 45.0°$. (This sector is shaded below.)



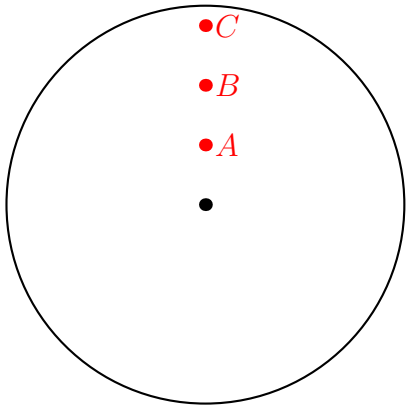
(c) The area of a triangle formed by the following lines:

- Secant AB.
- The line tangent to the circle at point A.
- The line tangent to the circle at point B.

Problem Solving

7. The speed of sound is $v = 1493\ \mathrm{m/s}$ in water, but through air the speed of sound is $v/4.35$. How long would it take sound to travel through $10\ \mathrm{m}$ of air?

8. Suppose the wheel shown below is spinning about its center (shown as an unlabeled dot). Which point is moving with the greatest speed?



   (a) A

   (b) B

   (c) C

   (d) They all move at the same speed.

9. The *angular velocity* of a point on a circle can be defined as the number of degrees per second through which that point rotates, relative to the center of the circle. According to this definition, which point from the circle in the previous problem has the greatest angular velocity?

   (a) A

   (b) B

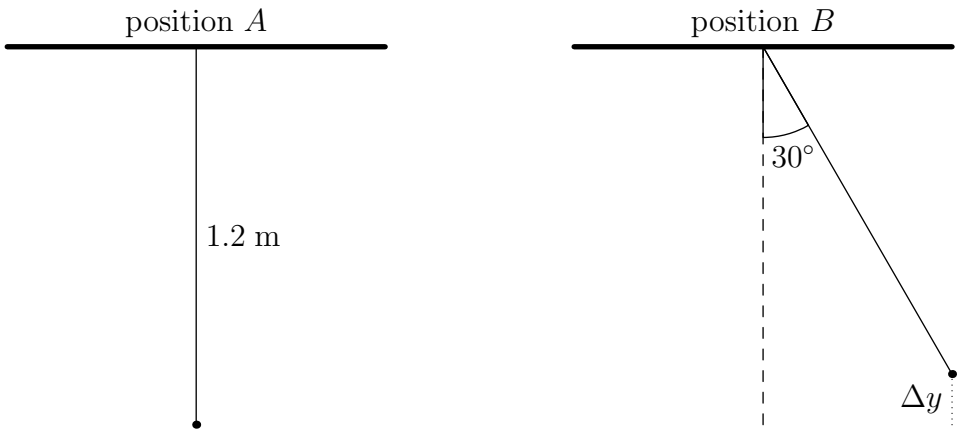
   (c) C

   (d) They all have the same angular velocity.

10. A *pendulum* is a small weight at the end of a string which hangs from the ceiling.

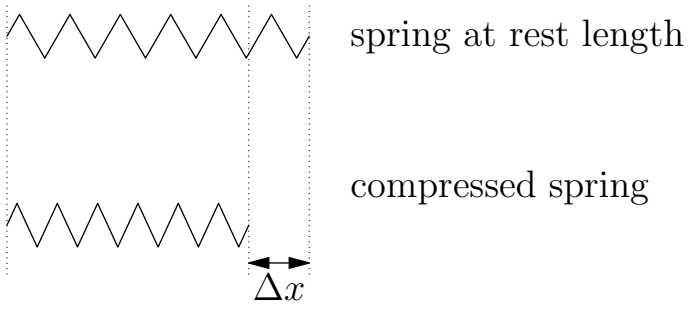
    In position A, a pendulum hangs straight down. In position B, the pendulum has been raised so that it makes an angle of 30° with the vertical.

    If the length of the pendulum is $1.2\ \text{m}$, by how much, Δy, has the pendulum been raised in moving from position A to position B?



11. A spring has a natural *rest length*, which is its length when there are no forces on it. When we apply a force to a spring, it gets shorter. This is *compression*. A compressed spring stores *elastic potential energy*. The formula for the elastic potential energy stored in a spring compressed by a distance Δx is

$$U = \frac{1}{2}k(\Delta x)^2.$$

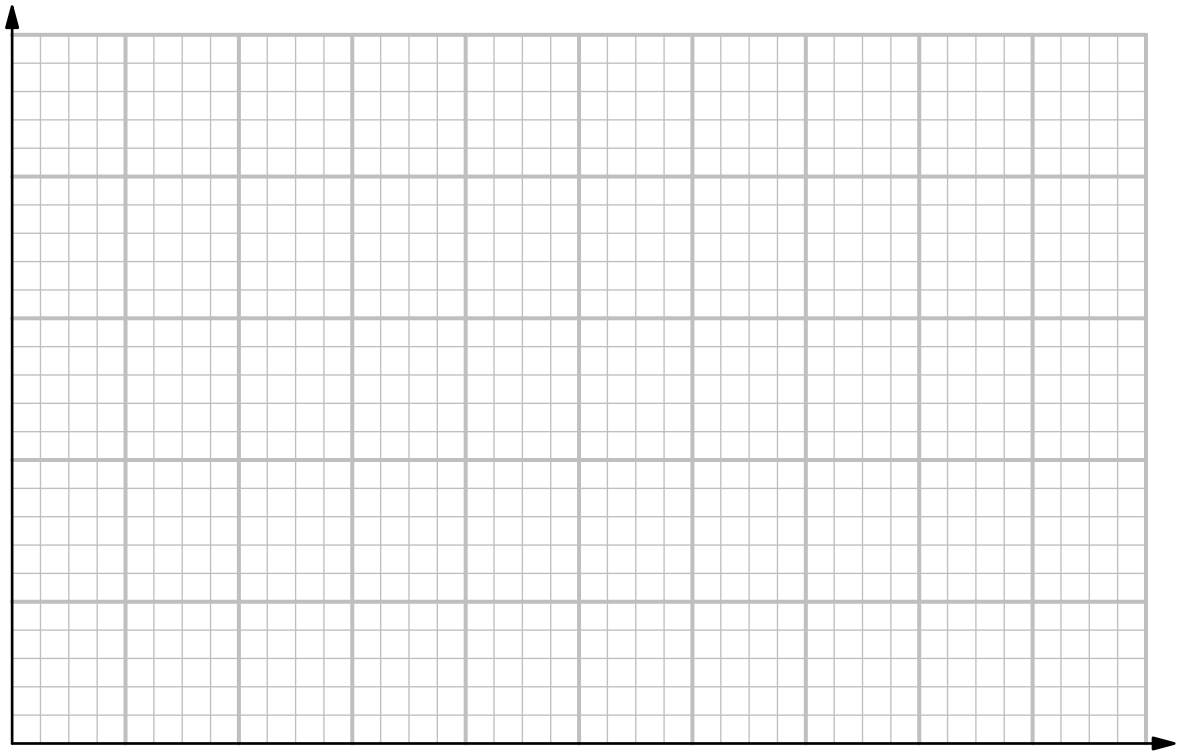


    k is a value that is different for each spring. It is called the *spring constant* and represents how stiff the spring is.

    According to this formula, which would have a bigger impact on the elastic potential energy stored in a spring: doubling the spring constant or doubling the distance that the spring is compressed?

12. Below is a data table for the force F exerted by a spring based on its length, ℓ. Plot the data and use your plot to estimate, as best you can, F when $\ell = 8.5\ \text{cm}$.

ℓ (cm)	F (N)
3.0	0.00
4.0	0.83
5.0	1.58
6.0	2.42
7.0	3.21

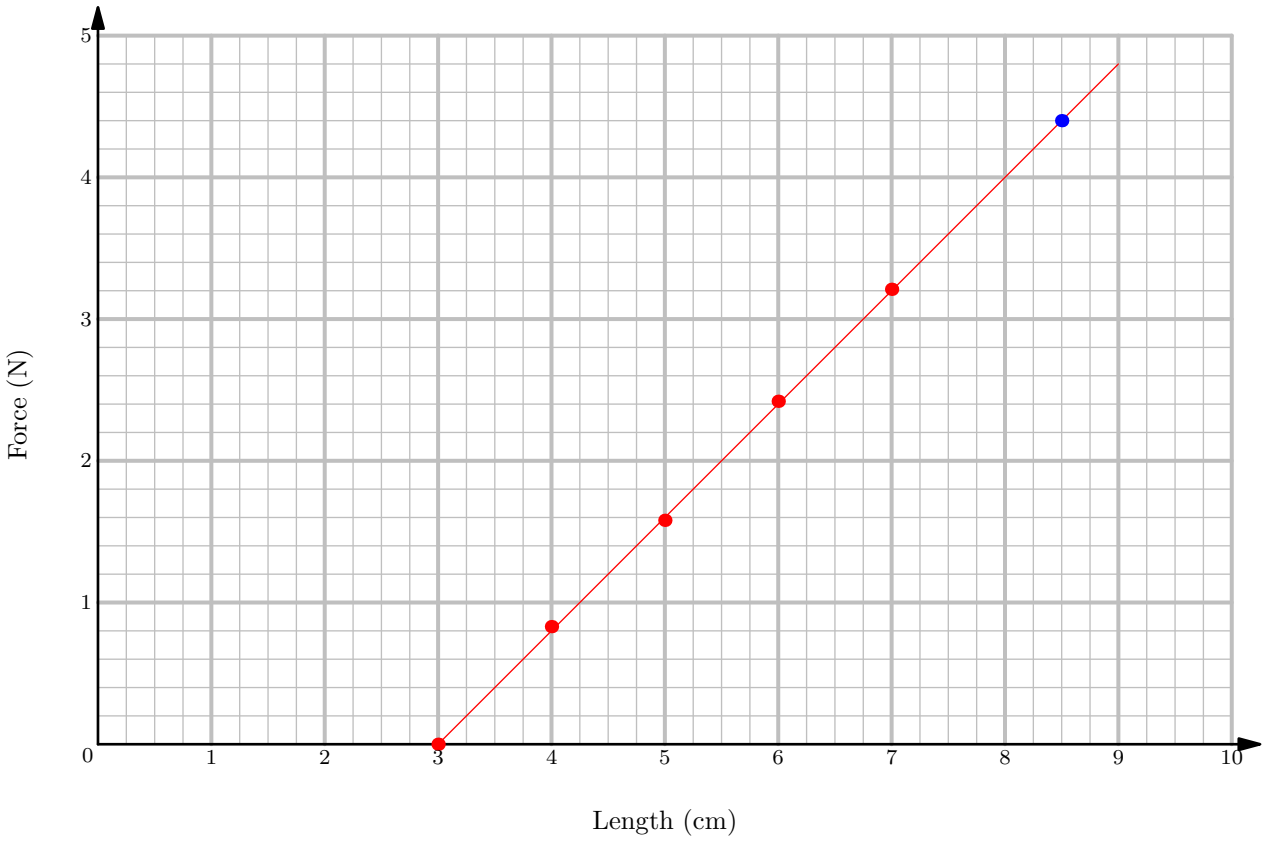


Don't look at the next page until you've attempted all the problems!

The answers are below.

1. (a) 1.69
   (b) 1023
   (c) $\frac{5}{12}$
   (d) $\frac{62}{5}$
2. (a) 0.348
   (b) $a = 2$; $b = -1$
   (c) $p = \frac{2mg}{v^2ac}$
3. (a) $(0.525, 19.5)$ (x coordinates in the range $0.51 \leq x \leq 0.54$ and y coordinates in the range $19.3 \leq y \leq 19.7$ are counted as correct.)
   (b) 4.5 or $\frac{9}{2}$ (Slope values in the range $4.4 \leq m \leq 4.6$ are counted as correct.)
   (c) $y = 4.5x + 5$ or $y = \frac{9}{2}x + 5$ (This is counted as correct if the slope in the previous problem was incorrect, but was used in place of the correct slope in this answer.)
4. $3\,000\,000$ or 3×10^6 (Also acceptable: $3\,000\,000$ cm or 3×10^6 cm.)
5. (a) 60°
   (b) 60°
   (c) 30°
   (d) 60°
6. (a) π (Also acceptable: decimal form, e.g. 3.14.)
   (b) $\frac{3}{2}\pi$ (Also acceptable: decimal form, e.g. 4.71.)
   (c) 2
7. 0.029 s
8. (c)
9. (d)
10. 0.16 m
11. doubling the distance the spring is compressed

12. 4.4 N (Values between 4.3 N and 4.5 N are counted as correct.)



(Also acceptable: same graph, but with x and y axes switched.)