AP® Physics 1
Measurement Set #1

/32

Name:_____
Period:_____

An average chicken egg has a mass of 50 grams. You weigh a bag of eggs and find a mass of 1840 grams.

1. What is the most likely number of eggs in the bag? **Show your work!**

2. Now you carefully count the eggs and find 39 eggs. What is the percent error of your predicted number of eggs? **Show your work!**

Greek philosopher/scientist Eratosthenes measured the circumference of the earth in the year 240 BC (1732 years before Columbus sailed). His equipment was: a hole in the ground, shadow made by sunlight, and very keen reasoning. His results were amazingly accurate. In his calculations, he used a unit of distance called a **stadia**. Since no one today is exactly sure how long the stadia is, there is some controversy about how accurate Eratosthenes's results are.

3. If we assume that Eratosthenes used the most common unit for stadia, then his measurement for the earth's circumference (converted to kilometers) is 46,620 km. An accepted value for the average circumference of the earth is 40,041.47 km. What is the percent difference between Eratosthenes's measurement and the accepted value? **Show your work!**

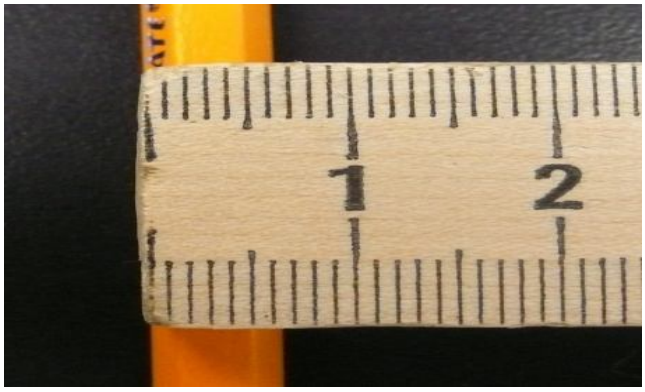
4. If we assume that he used a less common "Egyptian Stadium" as his unit for length, his result would be 39,690 km. What, in this case, would be the percent difference between Eratosthenes's measurement and the accepted value? **Show your work!**

Consider an experiment to determine the average acceleration of a ball dropped from a height of 1 meter. Students stand a meter stick on a table top and use a stopwatch to measure the time for the ball to fall from the top of a meter stick to the table. One student drops the ball and another student watches and carefully starts the watch.

5. Identify one possible source of <u>systematic</u> error for this experiment:

6. Identify one possible source of <u>random</u> error:

7. Determine the width of the pencil below, <u>including uncertainty</u>. The small graduation lines indicate millimeters.



8. What is the relative uncertainty of your reading in #7? (Remember to express the relative uncertainty as a percentage.) **Show your work!**

9. Compare your answers on questions 7 and 8 to the results from the measurement of the width of the lab table on page 10 (bottom) in the reading.

   a. Which measurement has greater absolute uncertainty? (circle one)

      pencil **table** **same**

   b. Which measurement has greater relative uncertainty? (circle one)

      pencil **table** **same**

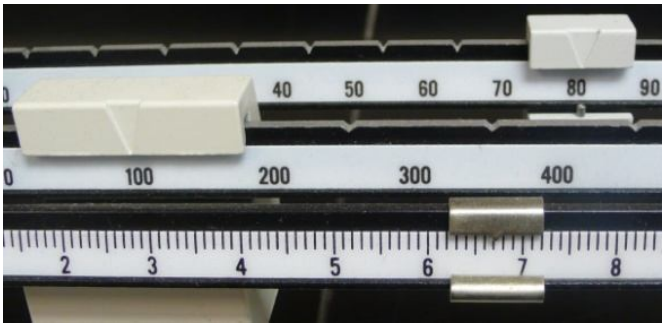
   c. Why is there such a difference in relative uncertainty in the two measurements?.

10. Determine the reading on the speedometer including uncertainty.

11. What is the relative uncertainty of your reading for question 10? **Show your work!**

12. Show this measurement on the number line below using error bars. (Be sure to include numbers!)

13. Determine the reading on the beam balance below, including uncertainty.



14. What is the absolute uncertainty of your reading?

15. What is the relative uncertainty of your reading?

16. The mass of a proton has been measured to be $(1.67262171 \pm .00000029) \times 10^{-27}$ kg. What is the absolute uncertainty (in kg of this measurement)?

17. What is the relative uncertainty (expressed as a percentage)?

18. Cosmologists currently calculate the age of the universe as $(13.73 \pm 0.12) \times 10^{9}$ years. What is the relative uncertainty of this measurement?

19. Consider a person who is 1.7 meters tall. If the height of this person were known to the same relative uncertainty as the age of the universe (question 18), what would be the absolute uncertainty (in centimeters)?

The reading on a digital stopwatch is 0.76 seconds.

20. If the manufacturer's specifications state a maximum error of 1%, determine the absolute and relative uncertainty.
    absolute:
    relative:

21. If the manufacturer's specifications state that the maximum error is 0.025 seconds, determine the absolute and relative uncertainty.
    absolute:
    relative:

22. If the manufacturer's specifications are not available, determine the absolute and relative uncertainty based on the certainty implied by the display.
    absolute:
    relative:

23. If we assume the person using the stopwatch adds an uncertainty of 0.25 seconds due to reaction-time, determine the absolute and relative uncertainty due to **reaction time only**.
    absolute:
    relative:

24. The analog gauge measures the rate of engine rotation in revolutions per minute (rpm) and the digital display shows fuel economy in miles per gallon (mpg). Express each reading in **x±Δx** form.

engine rotation

fuel economy

25. When using significant figures to express uncertainty, the uncertainty is half of the last decimal place. Using this method, find the absolute and relative uncertainty of mass of Mercury, which is 3.3022×10^{23} kg.
absolute:

relative:

Food manufacturers sometimes use significant figure rules to their advantage. For example, the manufacturer of this cereal claims "0 grams of trans fat per serving".

Nutrition Facts

Serving Size	About 24 biscuits (52g/1.8 oz.)	
Servings Per Container	About 9	
Amount Per Serving	**Cereal**	**Cereal with ½ Cup Vitamins A&D Fat Free Milk**
Calories	180	220
Calories from Fat	10	10
	% Daily Value**	
Total Fat 1g*	**2%**	**2%**
Saturated Fat 0g	**0%**	**0%**
Monounsaturated Fat 0g		
Polyunsaturated Fat 0g		
Trans Fat 0g		
Cholesterol 0mg	**0%**	**0%**

26. Using the form **x±Δx**, state the range of possible values that "0 grams" implies. As a hint, consider how many significant digits "0 grams" has.

27. Based on your previous answer what is the maximum of trans fat per serving that this cereal could contain?

28. What is the maximum amount of trans fat as a percentage of the biscuits in a serving (make sure you use the mass)?

29. Since it is not possible for the cereal to contain a negative amount of trans fat, what would be a clearer way to describe the amount of trans fat per serving.

30. Complete the tables below to find the average deviation for each set of measurements.

Time for ball to fall 1 meter (Lab Group 3)		
trial	time (s)	deviation (s)
1	0.42	
2	0.44	
3	0.46	
4	0.55	
5	0.43	
6	0.55	
average		**±**
Time=_____ ± _____ seconds		

Time for ball to fall 1 meter (Lab Group 4)		
trial	time (s)	deviation (s)
1	0.70	
2	0.31	
3	0.41	
4	0.57	
5	0.33	
6	0.41	
		±
Time= _____ ± _____ seconds		

31. Draw the range of values on a number line using error bars to show the range of uncertainty. Use the same scale for each graph.

Group 3

Group 4

32. Bearing in mind the theoretical value for the time for the ball to drop is 0.452 seconds, describe in words the difference between the measurements performed by Groups 3 and those done by Group 4. Hint: use the terms accuracy (page 2) and precision (page 10).