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Physics Workbook

The purpose of the *Physics Workbook* is to provide examples of a variety of types of problems you may face on the UIL Science Exam. By no means will it give an example of every type of problem that you may see. What it will do, however, is provide a foundation in basic calculations that can be used to solve the more complex physics problems you will face at the Regional and State Competitions. As you know, physics problems often involve using more than one concept in order to solve a problem. For example, you may have to calculate the amount of work done in a problem before you can calculate watts of power used.

By using this workbook you will not only improve your performance on the physics portion of the UIL Science test, but you should also improve your understanding of physics in the classroom as well. Take time to use both the *FlipCards* for physics and the *Concept Manuals* for physics from Hexco to increase your basic physics knowledge. Again, this workbook does not teach concepts, simply problem-solving methods and strategies, and example problems. Good luck on the UIL Science Test and good luck in your endeavors in science.

Helpful Physics Reminders:

- Take time to become familiar with **formulas.** The *FlipCards* for physics are a great method to accomplish this task.
- Look over the ***UIL Science Formula Sheet*.** This will let you know the constants and items you need to memorize and those you don't.
- Become extremely comfortable with the **dimensional analysis method** of problem solving.
- Look at the **units** in the answer to the problem. Many times this will let you know the mathematical operations necessary to solve the problem. Example: An answer to a problem uses the unit volts. You know that a volt is equal to 1 Joule/1 Coulomb; therefore, divide Joules by Coulombs in order to calculate the answer.
- Be very comfortable using the **metric system** and converting from one unit to another within the metric system.
- Although the graphing **calculator** typically is the norm for this test, all physics problems can be worked with a simple scientific calculator.
- **Significant digits** are the norm for all answers.
- Remember when using calculators to be in the **proper mode** for the operation at hand. (Radian and Degree modes in particular)
- **Work through the entire test** to ensure that you have given yourself the opportunity to answer any problems you might be familiar with.

Free-fall Acceleration

- Depends on the force of gravity.
- Velocity and distance are customarily assigned positive values when travelling away from the Earth, or up, and negative when going toward the Earth, or down.
- Velocity and distance are also customarily assigned negative values going West and positive going East on the coordinate plane. We will use this conventional method of assigning values to determine direction of travel throughout this workbook.
- **Use formulas from page 9, just replace *a* (acceleration) with *g* for acceleration due to gravity which in this book for calculations is 9.81 m/s/s.**
- Some use Δy instead of Δx because free fall is displacement in the y direction of a coordinate plane.

Example:

I "dropped" a penny off of a bridge in Colorado. It took 3.75 s to hit the water. How high is the bridge? a = 9.81 m/s/s t = 3.75 s vi = 0 m/s Δx (or Δy) = ?

Formula: $\Delta y = v_i (\Delta t) + (.5)(a)(\Delta t)^2$

$\Delta y = (.5)(-9.81 \text{ m/s/s})(3.75 \text{ s})^2 = -69.0 \text{ m}$ (negative means downward displacement)

Practice: Free-fall Acceleration :

11. A ball is thrown straight up into the air. It has a total hang time of 5.25 sec. What was its height at apogee? (highest point)

Height in meters = ____

12. A model rocket goes straight up at a velocity of 18.2 m/s. How long until it comes back to Earth?

Time =____

Newton's Universal Law of Gravitation

- Calculates forces that exist between all objects in the universe.
- Equation: $F_g = G \ (m_1 m_2 / r^2)$
- Where: Fg = force in Newtons m_1 and m_2 = mass in kg

  r = distance in m between objects

  G = universal gravity constant (6.673×10^{-11} Nm^2 / kg) On UIL formula sheet

Example:

Calculate the force of gravity between a golf ball (.189 kg) and a billiard ball (.325 kg) that are 25.5 cm apart from one another.

Formula: Fg = 6.673×10^{-11} Nm^2 / kg (.189 kg) (.325 kg) / (.255 m)^2

Fg = 6.30×10^{-11} N

Practice:

31. How far away would two objects be if their masses were 717.25 kg and 29.85 kg, and their gravitational force between them was 2.39×10^{-11} N?

Distance in meters = ____

32. What magnitude of gravitational force would be present between an 85.5 kg person on Earth if Earth's mass is 5.98×10^{24} kg and the average radius is 6.36×10^{6} m?

Gravitational Force =____

Rotational Motion if Angular Acceleration is Constant

- Formulas are similar as those for linear motion. Get familiar with linear, then you will know the ones for rotational motion.
  - $\omega_f = \omega_i + \alpha\Delta t$
  - $\Delta\theta = \omega_i \Delta t + ½ \alpha (\Delta t)^2$
  - $\omega_f^2 = \omega_i^2 + 2\alpha (\Delta\theta)$
  - $\Delta\theta = ½ (\omega_i + \omega_f) \Delta t$

Where: ω = angular velocity in rad/s α = angular acceleration in rad/s/s t = time
$\Delta\theta$ = angular displacement in rads

Example:

What is the angular displacement after 27.5 sec for a wheel that accelerates at a constant rate from rest to 38.5 rev /s in 2.12 minutes.

Time to seconds: (2.12 ~~min~~ / 1) (60 s/1 ~~min~~) = 127.2 sec

Revolutions / s to rad/s: (38.5 ~~rev~~/1 s) (2π rad/ 1 ~~rev~~) = 77π rad /s

Formula: $\Delta\theta = ½ (\omega_i + \omega_f) \Delta t$ (.5) (0 rad/s + 77π rad / s) (127.2s)

$\Delta\theta$ = 1.96 x 10^6 rad

Practice:

62. A car wheel accelerates at a rate of 18.2 rad/s/s. Its beginning angular velocity is 4.5 rad/s. What would the wheel's angular velocity be after 5 revolutions?

Angular velocity = ____

63. Calculate the angular acceleration of a unicycle wheel with a radius of 35.0 cm. It starts at rest and then rotates through 25 rads in 7.62 s.

Angular acceleration = ____

Tangential *Speed*

- Speed of an object at any point in a circular path.

- Formula: $v_t = r\,\omega$
- Where: v_t = m/s   r = radius in m   ω = angular velocity in rad/s

Example:

You throw a baseball with an angular velocity of 18.5 rad/s. Your arm is 72.0 cm long. What is the tangential speed of the ball at the time of release?

<u>Formula:</u> $v_t = r\,\omega$ v_t = .72 m (18.5 rad/s) **= 13.3 m/s**

Practice:

64. A wooden disk has a radius of 2.50 m and makes .745 turns / s. What is its tangential velocity?

Tangential velocity = ____

65. Calculate the radius of a ball on a string that is being spun around with a tangential velocity of 3.75 m/s making 1.99rev/s.

Radius = ____

<u>Tangential *Acceleration*</u>

- Change in velocity of an object in circular motion from one point to another point on the circle.