

Study Guide

Review for the Lab Exam

Experiment 2: Uncertainty in Measurements

- (1) A block is measured to have a mass $M = 25.3$ g and volume $V = 9.16$ cm³ with an uncertainty of $\Delta M = 0.05$ g in the mass and $\Delta V = 0.05$ cm³ in the volume. What is the uncertainty in the density?
- (2) You measure the lengths of three sides of a block and find $a = 12.23$ mm, $b = 14.51$ mm and $c = 7.45$ mm with an error of ± 0.03 mm in each measurement. What is the uncertainty ΔV in the volume of the block?
- (3) A block is measured to have a density $\rho = 2.76$ g/cm³ with an uncertainty of $\Delta\rho = 0.03$ g/cm³. Find χ^2 when the measured density is compared to the accepted density of pure aluminum $\rho = 2.70$ g/cm³.

Experiment 3: Position, Velocity and Acceleration

- (1) If a 1 cm block is placed under one leg of a 1.67-m air-track, what is the tilt angle of the air-track?
- (2) A cart starts at $x = 0.5$ m with an initial velocity of 1 m/s heading **up** the air-track. Assuming that the air-track is tilted at 0.01 radians, calculate the acceleration a and write the equation for the theoretical position as a function of time $x(t)$.

Experiment 4: Momentum and Drag

- (1) Two carts approach each other, collide, and stick together after the collision. This is an example of what type of collision: (a) perfectly inelastic collision, (b) inelastic collision, (c) elastic collision, (d) perfectly elastic collision, (e) sticky collision.
- (2) A cart with mass 0.3 kg and velocity 0.1 m/s collides on an air-track with a cart with mass 0.4 kg and velocity -0.2 m/s. If the final velocity of the first cart after the collision is -0.1 m/s, what is the velocity of the second cart?
- (3) Explain how the optical picket fence works and how this system can find the velocity of the cart. See the Experiment 4 manual for details about the picket fence if needed.
- (4) How can it happen that when two carts collide in this experiment, the total momentum of the two carts is not conserved?

Experiment 5: Centripetal Motion

- (1) If the motor is turning at 3000 RPM and the gear steps this motion down by a factor of 27, what is the frequency of the rotation of the mass in Hz?

- (2) Make a sketch that shows how the period of the rotating mass varies with the radius of the masses orbit (you may need to look at the manual or your data from this lab).
- (3) Using the formula

$$\tau = 2\pi \sqrt{\frac{r\sqrt{L^2 - (r - r_o)^2}}{g(r - r_o)}}$$

find the theoretical value for the rotation period τ for the mass when the height of the mass is $y = 0.07$ m, pendulum length $L = 0.20$ m, minimum height $y_0 = 0.02$ m, the extension arm length $r_0 = 0.02$ m, and $g = 9.801$ m/s².

Experiment 6: The Pendulum

- (1) Using a tape measure ruler, how precisely can you measure the length of the pendulum?
- (2) Why is it important to keep the angle small in this experiment?
- (3) What effect does the weight of the bob have in this experiment?
- (4) Is a calibration error in the timer a systematic or random error in determining g ? Can you overcome this by making more measurements with the same timer?

Experiment 7: Forced Harmonic Motion

- (1) Make a sketch that shows how the oscillation phase depends on frequency.
- (2) Make a sketch that shows how the oscillation amplitude depends on frequency.
- (3) Explain how you could measure the Q of the resonance in this system.
- (4) Suppose that you wanted to decrease the resonance frequency of the system, what could you do?
- (5) Suppose that you wanted to increase the quality factor Q of the system, what could you do?

Experiment 8: Waves on a String

- (1) How is the spacing between nodes of a standing wave related to the wavelength?
- (2) How is the velocity of the wave related to the mass hanging off the end?
- (3) What is the relationship between the frequency of a wave and its wavelength? Be sure to define any constants you introduce.
- (4) Sketch the shape of the string when it is excited in the third harmonic.

Experiment 9: Ideal Gas Law and Absolute Zero

- (1) Explain how we can use the Charles' Law apparatus to determine the absolute zero temperature.
- (2) Without using a thermometer, how might you establish a temperature of 100 °C?
- (3) What does "absolute zero temperature" mean?