

Physics 2A 2nd Midterm (200 Points MAX)

Spring 2005

Show your work with diagrams, explanations, and clear writings. No credit will be given for answers without diagrams, explanations, and clear writings.

- (a) How long must a simple pendulum be if it is to have a period of 10.0 s?

(b) If the period of a simple pendulum is T , what will its new period be if its length is increased by 50%?
- (a) A bug having a mass of 0.20 g falls into a spider's web, setting it into vibration with a dominant frequency of 18 Hz. Find the corresponding elastic spring constant.

(b) The human thigh bone, the femur, at its narrowest point resembles a hollow cylinder with an outer radius of roughly 1.1 cm and an inner radius of just about half of that. Taking the compressive strength of the bone to be 170 MPa, how much force will be required to rupture it?
- (a) A Texas pipeline carrying natural gas ($\rho = 0.90 \text{ kg/m}^3$) with a mass-rate of flow of 1.0 kg/s is 35 cm in diameter. Determine the average speed at which the gas is moving along.

(b) Gasoline (with a density of $0.68 \times 10^3 \text{ kg/m}^3$) is flowing in a pipeline having a 0.50-m diameter. Taking the fluid to be ideal, what pressure change results when the pipe descends 4.0 m down an embankment?
- (a) Determine the mass of helium needed to provide enough buoyancy (in dry air at 0°C) to lift a balloon and its load having a net mass of 454 kg. The load has a negligible volume.

(b) Derive the Bernoulli's equation using $\Delta W = (\Delta KE) + (\Delta PE_G)$.
- (a) A barber's chair rests on a hydraulic piston 10 cm in diameter. The input side a piston with a cross-sectional area of 10 cm^2 , which is pumped on using a foot pedal. If the chair and the client together have a mass of 160 kg, what force must be applied to the input piston?

(b) A hollow cylinder, or hoop, of mass m rolls down an inclined plane from a height h . If it begins at rest, show that its final speed is given by $v = \sqrt{gh}$.
- (a) Two lead spheres weighing 20.0 N and 10.0 N are separated 30.0 cm, center-to-center, by a horizontal weightless rigid rod. Locate the center-of-gravity of the system.

(b) Taking the Earth to be a uniform sphere of radius $6.37 \times 10^6 \text{ m}$ and mass $5.98 \times 10^{24} \text{ kg}$, compute its angular momentum about its spin axis.
- (a) During a rainy day football game, a 854-N (i.e., 192-lb) quarterback is standing holding the ball looking for a receiver when he's unkindly hit by a 1281-N (i.e., 288-lb) tackle charging in at 6.1 m/s (i.e., 20 ft/s). (i) At what speed do the two men, tangled together, initially sail off on the wet field? Assume friction is negligible and that the impact is head-on. (ii) How much mechanical energy is lost to friction?

(b) A rocket engine testing a low-power fuel expels 5.0 kg of exhaust gas per second. If these molecules are ejected at an average speed of 1.2 km/s, what is the thrust of the engine?
- (a) One ton of uranium-235 can provide about $7.4 \times 10^{16} \text{ J}$ of nuclear energy. If that much energy went into accelerating a $3.5 \times 10^6 \text{ kg}$ spaceship (that's the size of a fully loaded *Saturn V* Moon rocket) from rest, what would its final speed be?

(b) What is the kinetic and potential energy of a Boeing 747 airliner weighing $2.22 \times 10^6 \text{ N}$, flying at 268 m/s (i.e., 600 mi/h) at an altitude of 6.1 km (i.e., $20 \times 10^3 \text{ ft}$)?