

Physics 31A 2nd Midterm (200 Points MAX) – Test B

Fall 2004

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

- An essentially weightless helical spring hangs vertically. When a mass m is suspended from it, it elongates an amount ΔL . When let loose, it oscillates with a measured period of T . Show how you might use this arrangement to determine g .
 - Consider the frictionless cart in Fig. 1. If the elastic spring constants are k_1 , and k_2 , respectively, determine the frequency of vibration in terms of these quantities.



Fig.1

- 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?
 - If a uniform rod of cross-sectional area A and length L_0 can sustain a maximum stress of σ_R without

rupture, show that it stores an amount of elastic energy given by $PE_e = \frac{1}{2} \frac{AL_0\sigma_R^2}{Y}$ in getting to that stress level.

- 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.
 - Gasoline (with a density of 0.68 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?

- Figure 2 depicts a triangular plate submerged in a liquid of uniform density ρ . Show that the total hydrostatic force on one face of the plate is $F = \rho gb \left[\frac{a^2}{3} + \frac{h_0 a}{2} \right]$.

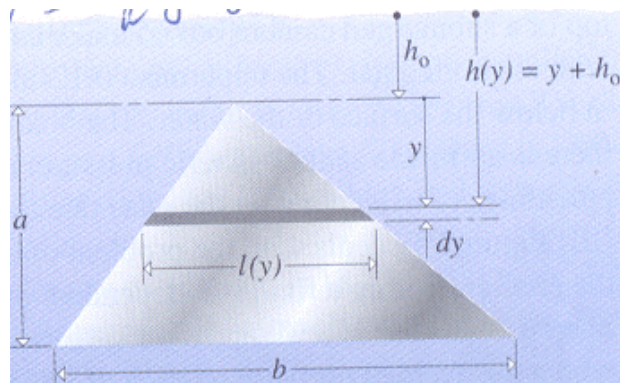


Fig. 2

- (b) A barber's chair rests on a hydraulic piston 10 cm in diameter. The input side has a piston with a cross-sectional area of 10 cm², 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?
5. (a) A long pencil is balanced straight up on its point on a horizontal surface. Without slipping, the pencil topples over. Show that the speed at which the eraser end strikes the surface is $v = \sqrt{3gL}$.
- (b) A long, uniform rod of length L is balanced vertically on one end, which rests on a rough horizontal floor. After a moment the rod begins to fall, rotating around its bottom end that remains where it was without slipping. The rod makes an angle θ with the vertical as it descends. Show that $w = \sqrt{(3g/L)(1 - \cos\theta)}$.
6. (a) Mounted in a bus is a 2.0-m-diameter flywheel, a massive disk often used to store rotational energy. If it is accelerated from rest at a constant rate of 2.0 rpm per second, what will be the angular speed of a point on the rim of the flywheel after 5.0 s? Through what angle will that point have rotated?
- (b) Imagine an extremely thin cylindrical shell of radius R and length L made of a uniformly dense material. If its total mass is M , determine its moment-of-inertia about its central symmetry axis.
7. (a) Two billiard balls, one heading north at 15.0 m/s and one heading south at 10 m/s, collide head-on. Take the collision to be perfectly elastic. What is the post-impact speed of each ball?
- (b) A 100-kg rocket held in place on the launchpad fires its engines. Once it is released, the rocket experiences a net upward force given by the expression $\vec{F}(t) = [40.0kN - (2.00kN/s)t - mg]\hat{k}$, for about 20.0 s. Assuming the mass is constant, find the change in momentum during the first 10.0 s.
8. (a) Find the lowest velocity \vec{V}_{esc} (escape velocity) with which we could fire a projectile straight up and never have it fall back to the planet earth from which it was launched.
- (b) A 70-kg passenger riding in a typical automobile is involved in a 17.9-m/s (i.e., 40 mi/h) head-on collision with a concrete barrier. Taking the stopping time as 100 ms, compute the average force exerted by the seat belt and shoulder strap on the person.