

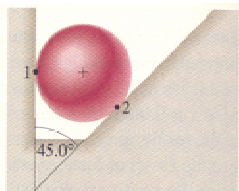
Physics 31A Final (300 pts MAX.)

Summer 2005

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

- (a) Consider the uniform cylinder of mass M , radius R , and length L . Use the calculus to determine its moment-of-inertia about the central y -axis.

(b) A sphere of mass 10.0 kg rests in a groove, as shown in Fig. 1. Assuming no friction and taking the weight of the sphere to act at its center, compute the reaction forces exerted by the two surfaces.



- (a) An automobile traveling at 20.0 m/s (i.e., 45 mi/h) blows a horn at a constant 600 Hz. Determine the frequency that will be perceived by a stationary observer both as it approaches and recedes. Take the speed of sound to be 340 m/s.

(b) Typically in dry air, the temperature of the atmosphere decreases by about 1°C for every rise of 150 m. Moreover, we saw that $v(T) = 331 \text{ m/s} + 0.60 T \text{ m/s}$, where T is the Celsius temperature. Thus, if a sound wave were traveling straight down through the atmosphere from a few thousand meters (neglecting density variations), determine its acceleration as a function of speed, $a(v)$.
- (a) A 100-liter storage tank is slowly being filled with gas. At 5.00 times atmospheric pressure, the tank holds 0.60 kg of gas. If the temperature is kept constant, how much gas will be in the tank when the pressure is raised to 10.00 atm?

(b) The coefficient of expansion of a typical material is not constant. For example, a metal like copper behaves, over a limited range of temperature, such that $\beta(T) = C_1 + C_2 T$ where C_1 and C_2 are rather small constants (of the order of 10^{-5} and 10^{-8} , respectively). If a sample is raised from some initial to some final temperature (in the range of applicability of the above expression), write a formula for the final volume in terms of the initial volume.
- (a) A pane of window glass is 0.90 m wide by 1.5 m high and 4.0 mm thick. It's a cold blustery winter's day in the Midwest. The temperature of the inside face of the window is 10°C , and the outside face is at -9.0°C . How much thermal power is being transported through the windows ($k_T = 0.84 \text{ W/m}\cdot\text{K}$)?

(b) Air is found to have a specific heat capacity over a range of temperature from 500K to 700K given by $c(T) = K_1 - K_2 T + K_3 T^2$ where K_1 , K_2 , and K_3 are constants and T is in kelvins. Find the amount of heat needed to raise the temperature of a mass m of air from T_i to T_f , within the range.
- (a) Use the calculus to prove that the work done by an ideal gas in an adiabatic process is given by
$$W = \frac{1}{1-\gamma} (P_f V_f - P_i V_i).$$

(b) A 20-kg sample of pure water at 40.0°C is mixed with a 20-kg sample of pure water at 32.0°C . Using the average temperatures of each sample, determine the approximate net change in entropy of the total quantity of water.