

Physics 31A Final (300pts MAX) Winter, 2004

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

1. (a) 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.

(b) A gas that obeys Boyle's Law is in a collapsible chamber, which is maintained at a constant temperature. At a given moment when the volume of the chamber is 550cm^3 and the pressure is 140 kPa, the chamber is being shrunk in volume. If the pressure is then changing at a rate of 60.0 kPa/min, what is the rate at which the volume is diminishing?
2. How much heat must be added to a 1.0-kg mass of water ice at -10°C and atmospheric pressure, in order to transform it into superheated steam at 110°C ?
3. (a) 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.

(b) A roast turkey (at time $t = 0$ and temperature $T = T_0$) is taken out of the oven to cool and placed on a table near an open window. Write an expression for its temperature as a function of time.
4. (a) Determine the maximum possible efficiency for a steam engine operating between 200°C and 27.0°C .

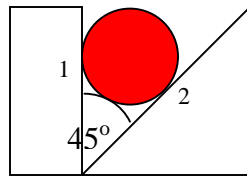
(b) By how much does its entropy change when a 10-kg block of ice at 0°C is completely melted into water at 0°C ?
5. (a) Use the calculus to prove that the work done by an ideal gas in an adiabatic process is given by $W = \frac{1}{1-\gamma} (P_f V_f - P_i V_i)$

(b) Suppose that an ideal gas undergoes an infinitesimal isothermal expansion; show that the change in its entropy is proportional to the fractional change in its volume. Discuss how this relates to the gas's increased disorder.
6. (a) A boy (mass 30 kg) wishes to play on a centrally pivoted seesaw with his dog Irving (mass 10 kg). When the dog sits 3.0 m from the pivot, where must the boy sit if the 6.5-m-long board is to be balanced horizontally?

(b) An object of volume V floats in water with a volume V_u up above the surface. (a) Write an expression for its average density in terms of the density of water. (b) Apply this solution to find the average density of a loaded barge with 20% of its volume above the waterline.

7. (a) Taking the Earth to be a uniform sphere of radius 6.37×10^6 m and mass 5.98×10^{24} kg, compute its angular momentum about its spin 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.



8. (a) A Texas pipeline carrying natural gas ($\rho = 0.90$ kg/m³) 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) Determine the change in the volume of a 1.00-m³ block of granite when it's submerged about 3 km in the ocean, where the pressure on all its surfaces is about 300 times ordinary atmospheric pressure (1.013×10^5 Pa).

9. (a) Typically in dry air, the temperature of the atmosphere decreases by about 1°C for every rise of 150 m. Moreover, $v(T) = 331$ m/s + $0.60T$ 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, $a(v)$.

(b) A wire having a mass of 60.0 g is 6.00 m long. If transverse waves travel along it at 200 m/s, what is the tension in the wire?