

Since the satellite has a surface area $4\pi r^2$ and a uniform temperature T it must radiate power

$$4\pi r^2 \sigma T^4 \epsilon.$$

At equilibrium the absorbed and radiated powers must be equal, so

$$r^2 \Omega \sigma T_s^4 \epsilon = 4\pi r^2 \sigma T^4 \epsilon,$$

which can be rearranged to give

$$T = T_s \left(\frac{\Omega}{4\pi} \right)^{1/4}.$$

- Taking $\Omega = 7 \times 10^{-5}$ sr and $T_s = 5800$ K gives $T = 280$ K.

[This problem gives a simplified understanding of the Earth's mean temperature, since the Sun subtends a mean solid angle of 6.80×10^{-5} sr at the Earth.]

Problem 172

A frictionless piston of mass m is a precise fit in the vertical cylindrical neck of a large container of volume V . The container is filled with a gas and there is a vacuum above the piston. The cross-sectional area of the neck is A .

(i) Calculate the pressure of the gas in the container when the piston is in equilibrium.

(ii) Assuming that the pressure and volume of the gas are related by Boyle's law, calculate the restoring force on the piston when it is displaced by a small distance x .

(iii) Assuming that the motion of the piston is slow enough for Boyle's law to be valid, obtain the differential equation for small displacements of the piston about its equilibrium position.

(iv) Show that the angular frequency of oscillation is independent of m .

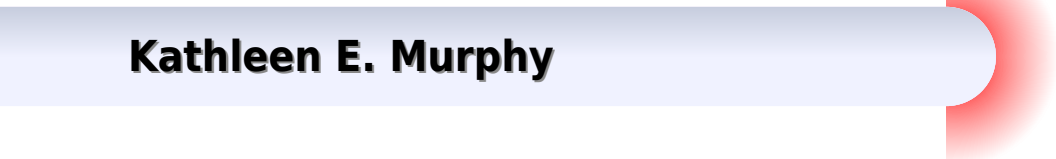
(v) Calculate ω for $V = 2000$ litres and $A = 1.0 \times 10^{-4}$ m².

Solution

- (i) The weight of the piston is mg , and this must be balanced by the upward force pA exerted by the gas pressure, so $p = mg/A$.
 (ii) Boyle's law states that pV is constant at constant temperature.

Thermodynamic Example Problems

Kathleen E. Murphy



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Thermodynamics Engineering Kalyan Annamalai, Ishwar K. Puri, Milind A. Jog, 2011-03-22 Advanced Thermodynamics Engineering Second Edition is designed for readers who need to understand and apply the engineering physics of thermodynamic concepts It employs a self teaching format that reinforces presentation of critical concepts mathematical relationships and equations with concrete physical examples and explanations of application *Thermodynamics and Energy Conversion* Henning Struchtrup, 2024-06-27 This comprehensive textbook covers engineering thermodynamics from beginner to advanced level The presentation is concise with material for about three full term university courses on 700 pages without compromising breadth or depth First and second law of thermodynamics are developed from everyday observations with accessible and rational arguments The laws of thermodynamics are applied to a multitude of systems and processes from simple equilibration processes over steam and gas power cycles refrigerators and heat pumps to chemical

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