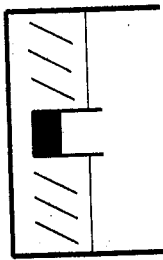


Dec 2005

Problem 2

You place a glass beaker partly filled with water, into a sink. The beaker itself has a mass of 390 grams and an interior volume of 500 cm³. You now start to fill the sink with water and you find that if the beaker is less than half full, it floats but if it is more than half full it sinks to the bottom.

What is the density of the glass making up the beaker?

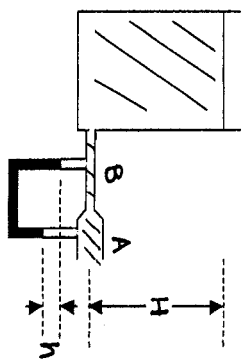


2786 kg/m^3

Problem 3

A very large reservoir, open at the top, is filled with water to a height $H = 15\text{m}$. It drains to the atmosphere through the cylinder at A which has cross-sectional area 0.200 cm^2 . At B, the cross-sectional area of the smaller pipe is 0.150 cm^2 . The rectangular tube below these cylinders contains mercury ($\rho = 13600 \text{ kg/m}^3$). Note: the drawing is not to scale.

What is the flow rate of water from the cylinder at A?



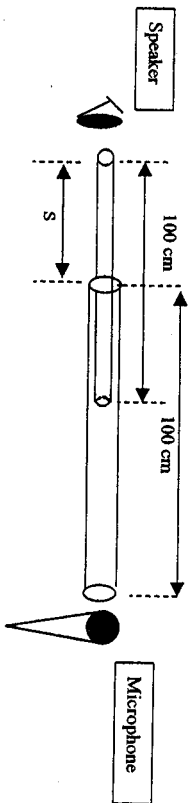
What is the velocity of water at B?

What is the height difference, h , between the two columns of mercury?

$3.43 \times 10^{-4} \text{ m}^3/\text{s}$
 22.9 m/s
 6.927 m

Problem 4

The device below has two moveable air tubes, which act as an open pipe of variable length (between 100 cm and 200 cm). On the left-hand side, a speaker emits sound waves at 280 Hz. For what values of extension S , do we expect to hear maximum sound at the microphone on the right end of the tubes? Note that we hear maximum sound when a standing wave is set up in the tube. Take the speed of sound in the air to be 343 m/s.

**Problem 5**

A sinusoidal wave is travelling along the positive x-axis on a string with a velocity of 40 m/s. The displacement of the particles of the string at $t = 2.0$ s is given by the equation

$$D(x,2) = 0.05 \sin(x - 81) \text{ m}$$

What are the wavelength and the frequency of the wave?

What is the phase constant of the wave?

$$2\pi \text{ m}, 6.4 \text{ Hz}, -1 \text{ rad}$$

Write a general equation for the wave, giving the displacement of the particles of the string as a function of position and time.

Problem 6

(a) In a science museum, a 50.0 kg brass pendulum bob is at the end of an 18.0 m long wire. The pendulum is started every morning at 7:00 am by pulling it 1.00 m to the side and releasing it. The damping constant, b , is 0.0100 kg/s (you may treat a damped pendulum like a damped mass-spring system).

(b) How many oscillations will the pendulum complete by 12:00 noon?

(c) What is its amplitude at 12:00 noon?

$$22.5 \text{ cm}$$

$$83.8 \text{ cm}$$

$$8.51 \text{ s}, 211 \text{ s}, 0.165 \text{ m}$$

Problem 7

A 20.0 N force stretches a vertical spring by 0.100 m

- (a) What mass must be added to the spring if it is to oscillate with a period of 0.800 s?

3.24 kg

- (b) If the amplitude of the motion is 0.100 m and the period is 0.800 s, what is the force (magnitude and direction) that the spring exerts on the mass when it is 0.0600 m below the equilibrium position and moving downward?

Problem 8

White light is incident from above on a flat thin film of thickness 320 nm and index of refraction $n = 1.38$. (In the air the visible spectrum lies between 650 nm - 420 nm). The thin film has air ($n = 1$) on both sides.

- a) What is the wavelength of red light (wavelength in air 630 nm) in the thin film?

- b) When viewed from above, for what wavelengths in the visible spectrum, would there be a constructive interference between the waves reflected from the top and bottom of the thin film? Show all work. Draw a diagram showing reflected waves.

- c) When viewed from below, for what wavelengths in the visible spectrum, would there be a constructive interference between the transmitted waves? Show all work. Draw a diagram showing the transmitted waves.

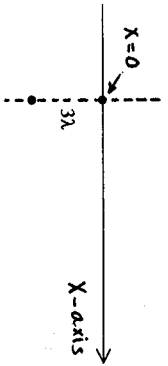
43.8 N upwards

456.5 nm, 588.8 nm, 441.6 nm

Problem 9

Two sources, in phase with each other and each emitting waves of wavelength λ , are separated a distance 3λ apart (as shown in the figure). The positive x-axis is perpendicular to the line joining the two sources.

(a) Write an expression, in terms of the wavelength λ , for the locations of points along the positive x-axis where the waves from the two sources will interfere constructively.

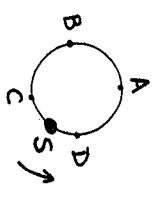


(b) Calculate the locations of the two points, in terms of the wavelength λ , nearest to the origin.

$4\lambda, 1.25\lambda$

Problem 10

A source S, rotating in a circle of radius 1.0 m with an angular velocity of 20.0 radians/s, is emitting sound waves of frequency 400 Hz. A stationary detector P is located far away. What frequencies will be detected by P for the waves emitted by the source when it is at the positions A, B, C and D on the circle? (linear velocity (v) = radius × angular velocity)



f_A = frequency detected for the waves emitted when the source is at A = 400 Hz
 f_B = frequency detected for the waves emitted when the source is at B = 378 Hz
 f_C = frequency detected for the waves emitted when the source is at C = 450 Hz
 f_D = frequency detected for the waves emitted when the source is at D = 425 Hz