

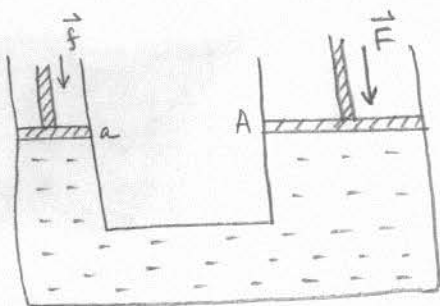
HOMEWORK 5

[PHY 121: MECHANICS]

DUE: MONDAY, JUNE 20, 2011

INSTRUCTOR: ARJIT BOSE.

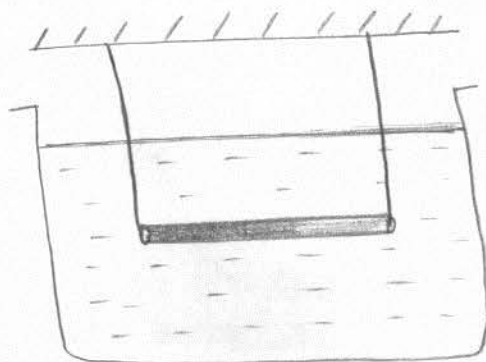
1)



The smaller piston has a cross-section of area a and the larger piston has an area A . If a small force $\vec{F}$ is exerted on the smaller piston.

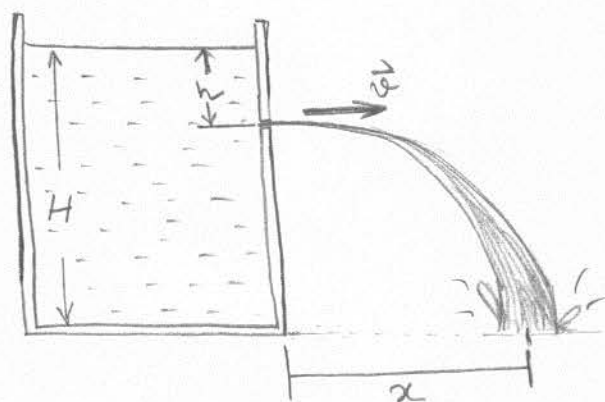
- a) What force magnitude F will the larger piston sustain without moving?
b) If the small piston has a diameter of 3.80 cm and the larger piston has a diameter of 53.0 cm , what force magnitude on the small piston will balance a 20.0 kN force on large piston?

- 2) A metal rod of length 80 cm and mass 1.6 kg has a uniform cross-sectional area of 6.0 cm^2 . Due to a nonuniform density, the center of mass of the rod is 20 cm from one end of the rod. The rod is suspended in a horizontal position in water by ropes attached on both ends (see figure). a) What is the tension in the rope closer to the center of mass b) What is the tension in the rope farther from the center of mass?



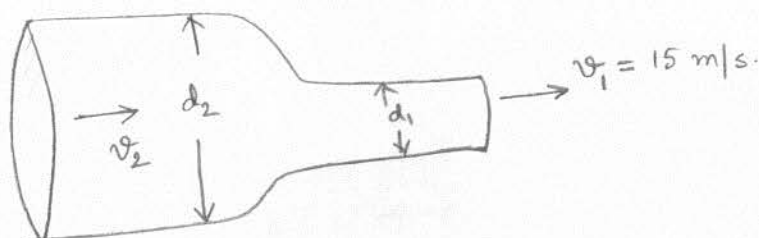
(3) A tank is filled with water to a height H . A hole is punched in one of the walls at a depth h below the water surface. (as in figure).

- (a) Show that the distance x from the base of the tank to the point at which the resulting stream strikes the floor is given by $x = 2\sqrt{h(H-h)}$
- (b) Could a hole be punched at another depth to produce a second stream that would have the same range? If so, what depth?
- (c) At what depth should a hole be placed to make the emerging stream strike the ground at the maximum distance from the base of the tank?

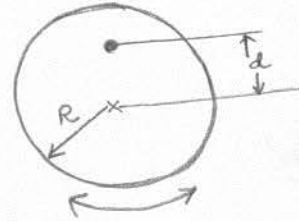


(4) Water flows through a horizontal pipe, and then out into the atmosphere at a speed of 15 m/s . The diameters of the left and right sections of the pipe are 5.0 cm and 3.0 cm , respectively

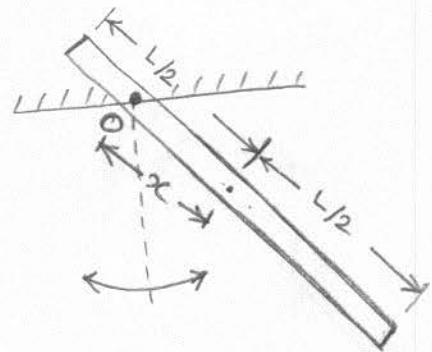
- (a) What volume of water flows into the atmosphere during a 10 min period?
- In the left section of the pipe, what are (b) the speed v_2 and (c) the gauge pressure?



- (5) A physical pendulum consists of a uniform solid disk (of mass M and radius R) supported on a vertical plane by a pivot located at a distance d from the center of the disk. The disk is displaced by a small angle and released. Find an expression for the resulting simple harmonic motion.

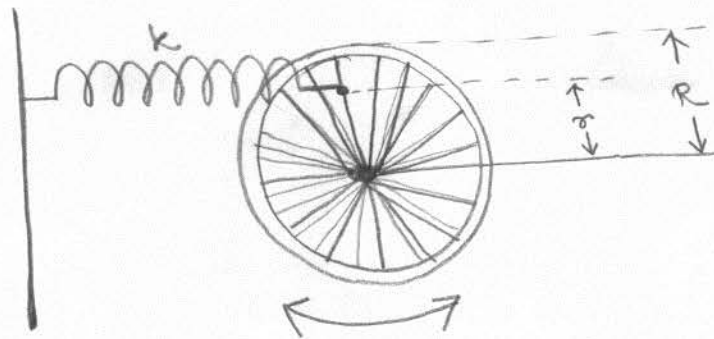


- (6) A stick with length L oscillates as a physical pendulum, pivoted about point O . (a) Derive an expression for the period of the pendulum in terms of L and x , the distance from the pivot point to the center of mass of the pendulum. (b) For what value of x/L is the period a minimum? (c) Show that if $L = 1.00 \text{ m}$ and $g = 9.80 \text{ m/s}^2$, this minimum is 1.53 s .



- (7) A wheel is free to rotate about its fixed axle. A spring is attached to one of its spokes a distance r from the axle, as in figure. (a) Assuming the wheel is a hoop of mass m and radius R , obtain the angular frequency of small oscillations of this system in terms of m , R , r , and the spring constant k . How does the result change if (b) $r = R$ and (c) $r = 0$?

[figure is on next page]



(8) Show that i) $y = y_m \sin(k(x - vt))$

ii) $y = y_m \sin 2\pi \left(\frac{x}{\lambda} - ft \right)$

iii) $y = y_m \sin \omega \left(\frac{x}{v} - t \right)$

iv) $y = y_m \sin 2\pi \left(\frac{x}{\lambda} - \frac{t}{T} \right)$

are all equivalent to $y = y_m \sin(kx - \omega t)$

(9) The type of rubber band used inside baseballs and golf balls obey Hook's law over a wide range of elongation of the band. A segment of this material has an unstretched length l and a mass m . When a force F is applied, the band stretches an additional length

Δl

(a) What is the speed (in terms of m , Δl , and the spring constant k) of transverse waves on this stretched rubber band?

(b) Using your answer to (a), show that the time required for a transverse pulse to propagate the length of the rubber band is proportional to

$\frac{1}{\sqrt{\Delta l}}$ if $\Delta l \ll l$ and is constant if $\Delta l \gg l$

(Note: This problem is not a compulsory problem to do, if you are able to do it you get special credit)