

Week 7 Challenge homework Solutions

Question 1:

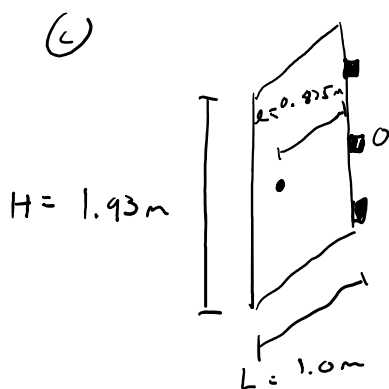
You are on a cruise ship to the Bahamas. The door to your room faces the outside of the ship, and swings inwards to your room. On a breezy day you notice that after turning the door knob, it is very difficult to pull the door open (legend has it, this happened to the mother of a friend of your instructor's cousin's dog's grandpa's owner). The wind is blowing steadily parallel to the side of the ship. **The wind is not at all directed into the door!**



- (a) What is the origin of the force preventing you from opening the door? Explain why the wind is making it difficult to open the door. Hint: if your door opened swinging outwards, it would be initially easy to open!
- (b) Your door is 1.00 meters wide and 1.93 meters tall. The door handle is 87.5 cm from the door hinges. If you have to exert a force of 45 lbs to start to open the door, how fast is the wind travelling outside your door? You may assume the force discussed in part (a) acts at the center of the door. Give the speed both in m/s and m/hr.

(a) ORIGIN OF FORCE IS A PRESSURE DIFFERENCE ACROSS DOOR W/
 LOWER PRESSURE ON INSIDE AND LOWER ON OUTSIDE.
 THE ΔP COMES FROM STATIC AIR ON INSIDE VS. MOVING
 AIR ON OUTSIDE.

(b) DOOR SWINGS INWARD. AS V INCREASES $P \downarrow$ SO
 OUTSIDE P IS LESS THAN P_{ATM} . ON INSIDE $P = P_{ATM}$



$$\tau_w + \tau_{HANDLE} = I_0 \alpha$$

$$\tau_w F_w - \tau_h F_h = 0$$

$$\frac{1}{2} L F_w - l F_h = 0$$

$$\frac{1}{2} L A \Delta P - l F_h = 0$$

$$P_{in} + \frac{1}{2} \rho v_{in}^2 + \rho g y_{in} = P_{out} + \frac{1}{2} \rho v_{out}^2 + \rho g y_{out}$$

$$P_{in} - P_{out} = \frac{1}{2} \rho v_{out}^2$$

$$\Delta P = \frac{1}{2} \rho v_{out}^2$$

$$\frac{1}{2} L A \frac{1}{2} \rho v_{out}^2 - l F_h = 0$$

$$\frac{1}{4} L (LH) \rho v_{out}^2 - l F_h = 0$$

$$v_{out} = \sqrt{\frac{4 l F_h}{\rho L^2 H}} \approx 17.2 \text{ m/s}$$

38.5 mph

Question 2:

In an engine, a piston oscillates with simple harmonic motion so that its position varies according to the expression $x(t) = 15.0 \cos(20.0 t)$ where x is in centimeters and t is in seconds.

- (a) What is the period of the motion?
- (b) What is the amplitude of the motion?
- (c) At $t = 1$ s, find the position of the piston.
- (d) At $t = 1$ s, find the velocity of the piston.
- (e) At $t = 1$ s, find the acceleration of the piston.
- (f) Sketch a plot of the acceleration as a function of time. Scale the plot properly.

$$X(t) = X_{max} \cos(\omega t)$$

(a) $\omega = \frac{2\pi}{T}$

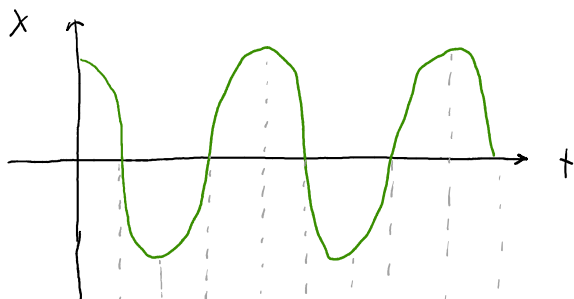
$$20 = \frac{2\pi}{T}$$

$$T = 0.314 \text{ SEC}$$

(b) $X_{max} = 15 \text{ cm}$

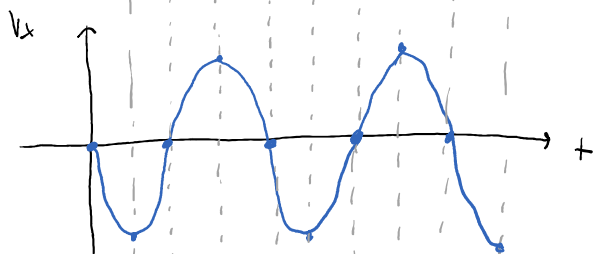
(c) $X(1) = 15 \cos(20(1))$

$$X(1) = 6.12 \text{ cm}$$



$$X(t) = X_{max} \cos(\omega t)$$

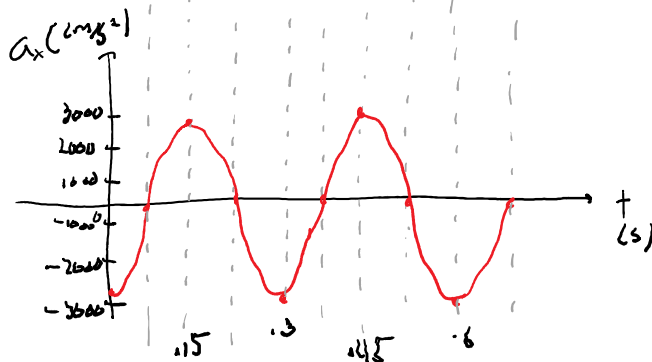
$$X(t) = 15 \cos(20t)$$



$$V_x(t) = -V_{max} \sin(\omega t)$$

$$V_x(t) = -X_{max} \omega \sin(\omega t)$$

(d) $V_x(1) \approx -274 \text{ cm/s}$



$$a_x(t) = -a_{max} \cos(\omega t)$$

$$a_x(t) = -X_{max} \omega^2 \cos(\omega t)$$

(e) $a_x(1) \approx -2450 \text{ cm/s}^2$