Name: Solutions

ID:

Physics 202

Quiz 3

8/12/2024

Collaboration is not allowed. Allowed on your desk are: three 8.5 x 11 inch doubled sided sheets of notes, any "survival sheets", a non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 40 minutes to complete this exam.

For questions 1 and 2, **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **4** correct answers in this section and only the first **4** filled in answers will be graded. There is no partial credit.

1. A wave travels along the x-axis and is described by the following equation of motion:

$$D_y(x,t) = 0.12\ \cos(3.4\,x + 0.27\,t)$$

Which of the following statements are true regarding this wave?

☐ (a) The **wavelength** of the wave is 0.27 m.

☑ (b) The **wavelength** of the wave is 1.85 m.

☐ (c) The **wavelength** of the wave is 3.4 m.

☐ (d) The **velocity** of the wave is 0.918 m/s.

☐ (e) The **velocity** of the wave is 0.032 m/s.

☐ (f) Because the displacement, D_y, is in the y direction, this wave is a **longitudinal** wave.

☑ (g) Because the displacement, D_y, is in the y direction, this wave is a **transverse** wave.

$$\lambda = \frac{2\pi}{k} = 1.85m$$

2. Water is flowing in a pipe (assume incompressible laminar flow as we have been in this course). Which of the following statements are true?

☐ (a) If the pipe **decreases** in height, the speed of the water must **increase**.

☐ (b) If the pipe **decreases** in height, the speed of the water must **stay the same**.

☑ (c) If the pipe diameter **increases**, the speed of the water must **decrease**.

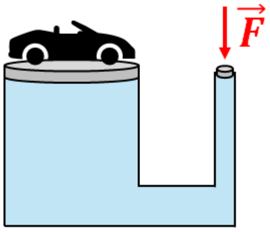
☑ (d) If the pipe diameter **decreases** and the pipe height **increases**, the pressure in the water must **decrease**.

☐ (e) If the pipe diameter **increases** and the pipe height **increases**, the pressure in the water must **decrease**.

$$A_1 v_1 = \underbrace{A_2}_{\uparrow} \underbrace{v_2}_{\downarrow}$$

$$A_1 v_1 = \underbrace{A_2}_{\downarrow} \underbrace{v_2}_{\uparrow} \Rightarrow P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = \underbrace{P_2}_{\downarrow} + \rho g \underbrace{y_2}_{\uparrow} + \frac{1}{2}\rho \underbrace{v_2^2}_{\uparrow}$$

3. (6 points) Using hydraulics and a relatively small force from your hand, you can lift very heavy object, such as your car. Using a setup as shown, you push down with a force, **F**, in order to hold your car stationary on the other end of the hydraulic system. Your car, being fairly light for a car, has a mass of only **961 kg**. The radius of the piston underneath the car is **0.45 meters**. The radius of the piston underneath your hand is **0.05 meters**. The incompressible oil inside the hydraulic system has a density of **840 kg/m³**. On Earth, at sea level, the average atmospheric pressure is **101,325 Pa.**

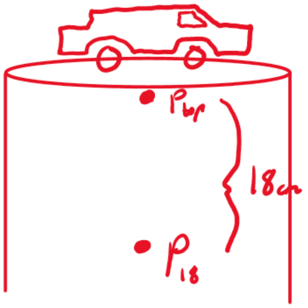


(a) What is the force, **F**, with which you push on the piston under your hand?

$$\frac{\overset{mg}{F_{car}}}{A_{car}} = \frac{F_{hand}}{A_{hand}} \Rightarrow \frac{(961\text{ kg})(9.8)}{\pi \underset{0.45m}{r_{car}^2}} = \frac{F_{hand}}{\pi \underset{0.05m}{r_{hand}^2}}$$

$$\Rightarrow F_{hand} = 116\text{ N}$$

(b) What is the absolute pressure at a point in the oil, **18 cm** below the piston holding the car? *(hint: don't forget about atmospheric pressure!)*



$$P_{18} = P_{top} + \underset{840\text{ kg/m}^3}{\rho} g (0.18m)$$

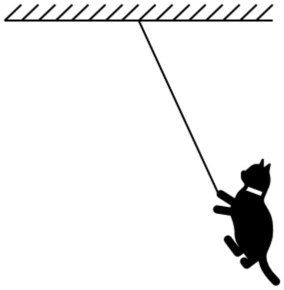
because atm pushes down on piston too:

$$P_{top} = P_{atm} + \frac{m_{car} g}{A} = 101{,}325\text{ Pa} + \frac{(961\text{ kg})(9.8\text{ m/s}^2)}{\pi (0.45m)^2}$$

$$= 116{,}000\text{ Pa}$$

$$\Rightarrow P_{18cm} = 117{,}600\text{ Pa}$$

4. (9 points) Aries the Acrocat swings on a pendulum at the circus (on Earth). The pendulum hangs 4.8 meters from the ceiling using massless rope. Aries has a mass of 3.9 kg. Aries swings from an initial angle of 12 degrees. Please show your work for full credit.



(a) How long does it take Aries to swing out and back to her starting position?

$$T = 2\pi\sqrt{\frac{L}{g}} = 4.40\,s$$

(b) Write an equation of motion ($\theta(t) = \ldots$) for Aries assuming no damping. This equation should be a function of time only. *(example:* $\theta(t) = 5t + 3b$*, is NOT an acceptable answer, since it also depends on b)*

$$\left.\begin{array}{l} \theta_{max} = 12^\circ \\ \omega = \sqrt{\frac{g}{L}} = 1.43\,\frac{rad}{s} \end{array}\right\} \qquad \theta(t) = 12^\circ \cos\left(1.43\,\frac{rad}{s}\,t\right)$$

(c) After swinging for 12.5 seconds, the amplitude of Aries oscillation has decreased to 7.8 degrees. What is the time-constant of the damping, τ ?

$$Amp(t) = \theta_{max}\, e^{-t/\tau}$$

$$Amp(t = 12.5\,s) = \underbrace{7.8^\circ = 12^\circ\, e^{-12.5\,s/\tau}}$$

$$0.65 = e^{-12.5\,s/\tau}$$

$$\tau = 29.0\,s$$