

PHYSICS 126 – Midterm 1

Name: _____

Student ID: _____

Answer the questions in spaces provided on each sheet. If you run out of room for an answer, continue on the back.

Question	Points	Score
1	25	
2	35	
3	40	
4	25	
5	30	
6	30	
Total	185	

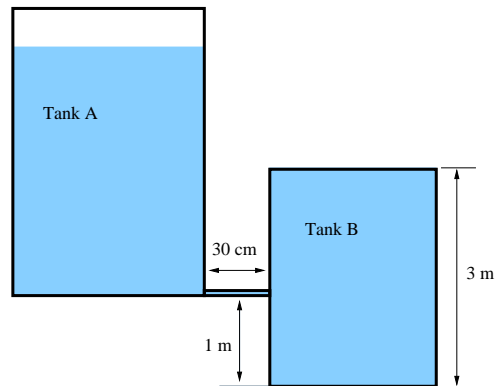
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Formulas

$$\begin{aligned}
 \rho &= m/V & P &= F/A \\
 P &= \rho gh & \frac{dP}{dy} &= -\rho g \\
 P_2 - P_1 &= -\rho g(y_2 - y_1) & P &= P_0 + \rho gh \\
 \frac{F_{out}}{F_{in}} &= \frac{A_{out}}{A_{in}} & \rho_1 A_1 v_1 &= \rho_2 A_2 v_2 \\
 P_1 + \frac{1}{2}\rho_1 v_1^2 + \rho g y_1 &= P_2 + \frac{1}{2}\rho_2 v_2^2 + \rho g y_2 & W &= F\Delta x \\
 E_{kin} &= \frac{1}{2}mv^2 & F &= \eta A \frac{v}{l} \\
 Q &= \frac{\pi R^4 \Delta P}{8\eta L} & F &= -kx \\
 f &= 1/T & \frac{d^2x}{dt^2} + \frac{k}{m}x &= 0 \\
 \omega &= \sqrt{\frac{k}{m}} & x &= A \cos(\omega t + \phi) \\
 \omega &= 2\pi f = \frac{2\pi}{T} & E_{tot} &= \frac{1}{2}kA^2 \\
 U &= \frac{1}{2}kx^2 & v_{max} &= \omega A \\
 v &= \pm \sqrt{\frac{k}{m}(A^2 - x^2)} & \sin \theta &\approx \theta \\
 \cos \theta &\approx 1 - \theta^2 & d \cos \theta &= -\sin \theta \\
 d \sin \theta &= \cos \theta & \omega &= \sqrt{\frac{g}{L}} \\
 \omega &= \sqrt{\frac{K}{I}} & F_{damp} &= -bv \\
 m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx &= 0 & x &= Ae^{-\alpha t} \cos(\omega' t + \phi) \\
 \alpha &= \frac{b}{2m} & \omega' &= \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}} \\
 f &= \frac{\omega'}{2\pi} & v &= \lambda f \\
 v &= \sqrt{\frac{E_T}{\mu}} & v &= \sqrt{\frac{E}{\rho}} \\
 v &= \sqrt{\frac{E}{\rho}} & \bar{P} &= 2\pi^2 \rho A v f^2 D_m^2 \\
 I &= \bar{P}/A & D(x, t) &= D_m \sin\left[\frac{2\pi}{\lambda}(x - vt)\right] \\
 D(x, t) &= D_m \sin\left(\frac{2\pi}{\lambda}x - \frac{2\pi}{T}t\right) & D(x, t) &= D_m \sin(kx - \omega t) \\
 \frac{\partial D}{\partial x} - \frac{1}{v^2} \frac{\partial D}{\partial t} &= 0 & Re &= \frac{2\bar{v}r\rho}{\eta} \\
 P_{atm} &= 100 \text{ kPa} = 1 \times 10^5 \text{ N/m}^2 & g &= 9.8 \text{ m/s}^2
 \end{aligned}$$

Material	Young's Modulus	Density	Viscosity
Iron, cast	$100 \times 10^9 \text{ N/m}^2$	$7.8 \times 10^3 \text{ kg/m}^3$	
Steel	$200 \times 10^9 \text{ N/m}^2$	$7.8 \times 10^3 \text{ kg/m}^3$	
Brass	$100 \times 10^9 \text{ N/m}^2$	$8.9 \times 10^3 \text{ kg/m}^3$	
Aluminum	$70 \times 10^9 \text{ N/m}^2$	$2.7 \times 10^3 \text{ kg/m}^3$	
Granite	$45 \times 10^9 \text{ N/m}^2$	$2.7 \times 10^3 \text{ kg/m}^3$	
Air		1.3 kg/m^3	$1.8 \times 10^{-5} \text{ Pa}\cdot\text{s}$
Water		$1 \times 10^3 \text{ kg/m}^3$	$1.8 \times 10^{-5} \text{ Pa}\cdot\text{s}$

1. A water tank, 3.7 m deep and 2 m in diameter, is connected at the bottom to a second water tank by using a 2 cm diameter pipe (see the figure). The tank A is open to the air and tank B is filled to the top and sealed.



- 5 (a) What is the mass of the water in tank A?
- 5 (b) What is the gauge pressure at the bottom of tank A?
- 5 (c) What is the absolute pressure at the bottom of tank B?
- 10 (d) What is the net force on the top of tank B?

2. An airplane has a 50 m^2 wing that is designed so that air on the top travels 20% faster than the air on the bottom. The air on the bottom of the wing moves at the plane's airspeed and the unloaded airplane has a take-off speed of 90 km/h.

5 (a) What is the velocity of the air on top of the wing as the unloaded airplane becomes airborne?

10 (b) What pressure difference between the top and bottom of the wing as the unloaded airplane becomes airborne?

5 (c) What is the mass of the unloaded airplane?

15 (d) If on a particular day, the mass of the airplane is increased by 10%, what is the new take-off speed?

3. A mass, m , hangs from a string and swings with a frequency of 0.8 Hz with a maximum displacement of 0.1 rad. The equation of motion is given by $x = A \cos(\omega t)$.

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(a) What is the length of the string?

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(b) What is the maximum displacement of the mass in meters?

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(c) What is the velocity of the mass as a function of time? Leave the answer as a function of m , g , L , and θ_{max} (Hint: Take the derivative of the equation of motion).

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(d) What is the restoring force acting on the mass as a function of time? Leave the answer as a function of m , g , L , and θ_{max} (Hint: Find the acceleration).

4. A boat is on a quiet lake 200 m from a paddle wheel that creates waves which pass the boat every 1.8 s with an amplitude of 3 cm.

5 (a) If the wave velocity for water waves is 1.5 m/s, what is the wavelength?

10 (b) Write an equation for the displacement of the water as a function of position and time?

10 (c) What is the amplitude of the wave if the boat is moved 60 m closer to the paddle wheel?

5. A longitudinal wave travels down a 1 cm diameter cast iron rod with a frequency of 20000 Hz.

10 (a) What is the wave velocity?

5 (b) What is the wavelength?

15 (c) If 500 W of power is transported by the wave, what is the maximum displacement of a small volume element of the rod?

30 6. The one dimensional wave equation is

$$\frac{\partial^2 D}{\partial x^2} - \frac{1}{v^2} \frac{\partial^2 D}{\partial t^2} = 0.$$

Demonstrate that $D = D_m \sin \omega t \cos kx$ is a solution.