Name:_____

Student ID #:_____

Signature:_____

October 8, 2021

Physics 1B Midterm #1, version A

- You have 50 minutes to complete this exam. You MUST close the exam and hand it in at the front when time is up. Show your student ID when handing in your exam. If we have to come collect your exam from your row, your exam will be marked so that 25% will be immediately deducted.

- Numerical values in answers: quote values with 3 significant figures, for example, 1.32 or 9.72. Always specify the units, even for intermediate results, and quote your final answer in SI units unless indicated otherwise.

- Exam rules:

    - The last sheet of the exam is an equation sheet that may be torn off. Do not write on the equation sheet.
    - You can use any type of calculator that does not have internet capability. Put away your cell phones and laptops.
    - Questions during the exam – you may raise your hand if you are seated near the end of a row, otherwise, unfortunately, you may need to come down to the front to ask.

- You MUST sign and date the 2nd page entitled "Academic Integrity – A Bruin's Code of Conduct" in order to receive credit for your work.

- Remember to write down each step of your calculation, and explain your answers fully.

Score :

I.	(Mult choice)	_____/10 points
II.		_____/10 points
III.		_____/10 points
IV.		_____/10 points
	Total	_____/40 points

Academic Integrity - A Bruin's Code of Conduct:

UCLA is a community of scholars committed to the values of integrity. In this community, all members including faculty, staff, and students alike are responsible for maintaining the highest standards of academic honesty and quality of academic work. As a student and member of the UCLA community, you are expected to demonstrate integrity in all of your academic endeavors. When accusations of academic dishonesty occur, the Office of the Dean of Students investigates and adjudicates suspected violations of this student code. Unacceptable behavior include cheating, fabrication or falsification, plagiarism, multiple submissions without instructor permission, using unauthorized study aids, facilitating academic misconduct, coercion regarding grading or evaluation of coursework, or collaboration not authorized by the instructor. Please review our campus' policy on academic integrity in the UCLA Student Conduct Code: https://deanofstudents.ucla.edu/individual-student-code

If you engage in these types of unacceptable behaviors in our course, then you will receive a zero as your score for that assignment. If you are caught cheating on an exam, then you will receive a score of zero for the entire exam. These allegations will be referred to the Office of the Dean of Students and can lead to formal disciplinary proceedings. Being found responsible for violations of academic integrity can result in disciplinary actions such as the loss of course credit for an entire term, suspension for several terms, or dismissal from the University. Such negative marks on your academic record may become a major obstacle to admission to graduate, medical, or professional school.

We cannot make exceptions to our campus' policy on academic integrity, and as we hopefully have communicated effectively here, penalties for violations of this policy are harsh. Please do not believe it if you hear that "everyone does it". The truth is, you usually don't hear about imposed disciplinary actions because they are kept confidential. So our advice, just don't do it! Let's embrace what it means to be a true Bruin and together be committed to the values of integrity.

By submitting my assignments and exams for grading in this course, I acknowledge the above-mentioned terms of the UCLA Student Code of Conduct, declare that my work will be solely my own, and that I will not communicate with anyone other than the instructor and proctors in any way during the exams.

_____ _____

Signature Date

_____ _____

Print Name UID

I) Multiple Choice - circle the *one* correct answer to each question.

1. An engineer replaces a tall load-supporting column in a building with a thinner one that has the same height but half the cross-sectional area. As a result of this replacement, what happened to the stress on the column? (Ignore the relatively small change in load due to the decreased weight of the column itself.)

    a. It stayed the same.
    b. It doubled.
    c. It was reduced by a factor of two.
    d. We are not given enough information to say.

2. In a horizontal length of circular pipe, the speed of a fluid having non-zero viscosity that is moving in normal "laminar" flow within a depends on cross-sectional position within the pipe as follows:

    a. The speed is chaotic and not predictable.
    b. The speed is zero at the center of the pipe but increases close to the walls.
    c. It has the same speed at all positions within the pipe.
    d. The speed is highest at the center of the pipe, going down to zero right next to the wall.
    e. The speed is highest at the top of the fluid, going down to zero at the bottom.

3. If we know the pressure inside the pressurized water tank of an old "Super Soaker" water gun, the speed of water shot out can be easily calculated using:

    a. The continuity equation.
    b. Archimedes principle.
    c. The bulk modulus of water.
    d. The acceleration of gravity.
    e. Bernoulli's equation.

4. You have a cubic vessel which has outer dimensions 20x20x20 cm^3 and wall thickness of 1 cm. The vessel is sitting in air in Los Angeles on a nice sunny day, and the air inside of the vessel has been completely pumped out by a vacuum pump. Which of the following statements is true?

    a. The inward force due to pressure is approximately the same on all walls of the vessel.
    b. The inward force due to pressure is much higher on the bottom of the vessel than anywhere else.
    c. The inward force due to pressure is much higher on the top of the vessel than anywhere else.
    d. There is no inward force on the walls, as it is compensated by outward force due to air pressure.
    e. There is a large outward force on all walls of the vessel due to atmospheric pressure.

5. The continuity equation follows from what physical principle:

    a. Conservation of energy.
    b. If a fluid is not moving, there cannot be any shear force on it.
    c. If a fluid is not moving, there must be zero net force on any part of it.
    d. Heat is actually due to the movement of molecules.
    e. Conservation of mass.

II (10 points): Since July 2016, new showerheads in California are limited to 2.0 gallons per minute, which is 0.126 liters/second. Suppose the inner diameter of the water pipes in a house is ½-inch (1.27 cm).

a) (5 pts) What is the average speed of water in such a pipe connected to one such showerhead?
b) (5 pts) Suppose the gauge pressure in the water coming into a house at ground level is 1.8 atm. What will the gauge pressure, in atmospheres, be at the top of the third story of the house 9.0 meters above ground level when no water is flowing?

showerheads: $0.126\ L/s = 0.126 \times 10^{-3}\ m^3/s$

pipes' d: $d = 1.27\ cm = 1.27 \times 10^{-2}\ m$

$r = 0.635 \times 10^{-2}\ m$

$dV/dt = 0.126 \times 10^{-3}\ m^3/s$

$A = \pi r^2 = \pi (0.635 \times 10^{-2}\ m)^2 = 1.27 \times 10^{-4}\ m^2$

a) $v = \frac{dV/dt}{A} = \frac{0.126 \times 10^{-3}\ m^3/s}{1.27 \times 10^{-4}\ m^2} = \underline{0.99\ m/s}$

accepted: b) $P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

$P_1 = 1.8\ atm = 181800\ Pa = N/m^2$

$y_1 = 0$

$y_2 = 9\ m$, $v_2 = 0$, $v_1 \neq 0$

$\Rightarrow P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2$

$P_2 = P_1 + \frac{1}{2}\rho v_1^2 - \rho g y_2$

$= 181800\ Pa + \frac{1}{2} \times 1000\ kg/m^3 \times (0.99\ m/s)^2 - 1000\ kg/m^3 \times 9.8\ m/s^2 \times 9\ m$

$= \underline{94090\ Pa}$

also accepted: $P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$; $v_1 = 0$, $v_2 = 0$

$P_2 = P_1 - \rho g y_2$

$= 181800\ Pa - 1000\ kg/m^3 \times 9.8\ m/s^2 \times 9\ m$

$= \underline{93600\ Pa}$

III (10 points) The *mass* of a common housefly is about 15 milligrams. Spider silk has a circular cross-section that is typically 0.002 mm in diameter, and a Young's modulus of about 1.0 GPa (Giga means billion). Suppose that spider silk can be stretched about 10% of its length before breaking. Remember to express your answers in SI units.

a) (3 pts) What is the cross-sectional area of a strand of spider silk?
b) (3 pts) What stress is created by a strand of a spider web supporting the weight of a housefly?
c) (4 pts) What strain would such a strand experience? Would the spider silk break?

$m = 15\,mg$, $d = 0.002\,mm$, $Y = 1.0 \times 10^9\,Pa$

$\frac{\Delta L}{L} = 10\%$

a) $A = \pi\left(\frac{d}{2}\right)^2 = \pi \times (6.001 \times 10^{-3}\,m)^2 = 3.14 \times 10^{-12}\,m^2$

b) $\sigma = \frac{F}{A} = \frac{mg}{A} = \frac{15 \times 10^{-6}\,kg \times 9.8\,m/s^2}{3.14 \times 10^{-12}\,m^2} = 4.68 \times 10^7\,Pa$

c) $\varepsilon = \frac{\sigma}{Y} = \frac{4.68 \times 10^7\,Pa}{1.0 \times 10^9\,Pa} = 0.0468 = 4.68\% < 10\%$

100

IV (10 points): Suppose a 2.5 N force can rupture an eardrum having an area of 0.5 cm^2.

a) (3 pts) What gauge pressure would produce such a force?
b) (2 pts) Explain in words why gauge pressure, rather than absolute pressure, is relevant.
c) (5 pts) Calculate the maximum depth a scuba diver should go in the ocean in order to avoid such damage.

$F = 2.5\,N$, $A = 0.5\,cm^2 = 0.5 \times 10^{-4}\,m^2$

a). $P = \frac{F}{A} = \frac{2.5\,N}{0.5 \times 10^{-4}\,m^2} = 5 \times 10^4\,Pa$ = gauge pressure

b).
- definition of gauge pressure: Pressure above P_{atm}
- the eardrum sustains atmosphere already in air.

$P_{gauge} = P_{absolute} - P_{atm}$.

c).

$P = \rho g h \Rightarrow h = \frac{P}{\rho g} = \frac{5 \times 10^4\,Pa}{1000\,kg/m^3 \times 9.8\,m/s^2}$

$= 5.1\,m$

Midterm 1 possibly useful constants:

$g = 9.8\ {}^{m}/_{s^2}$ on Earth

$\rho(water) = 1000\ kg/m^3$

$\rho(air) = 1.30\ kg/m^3$ near sea level

$p_{atm} = 1.01 \cdot 10^5\ N/m^2$

Midterm 1 possibly useful equations:

$$Y = \frac{Tensile\ stress}{Tensile\ strain} = \frac{F_\perp / A}{\Delta l / l_0}$$

$$B = \frac{Bulk\ stress}{Bulk\ strain} = \frac{\Delta p}{\Delta V / V_0}$$

$$Shear\ stress = F_\parallel / A$$

$$\rho = {}^{m}/_{V}$$

$$p = \frac{dF_\perp}{dA}$$

$$p_2 - p_1 = -\rho g(y_2 - y_1)$$

$$p = p_0 + \rho g h$$

$${}^{dV}/_{dt} = A_1 v_1 = A_2 v_2$$

$${}^{dm}/_{dt} = \rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

$$p + \rho g y + \frac{1}{2}\rho v^2 = constant$$