It's on your seating label!

**Name:** ____________________  **Section:** ________

**Instructions**
- Do not open the exam until instructed to do so.
- Do not leave if there is less than 5 minutes to go in the exam.
- When time is called, immediately stop writing, remain seated, and pass your exam to the center aisle.
- Do not stand up or leave until all exams have been collected.
- **Working after time is called results in an automatic 10 point deduction.**

**Guidelines**
- Assume 3 significant figures for all given numbers unless otherwise stated
- Show all of your work – **no work, no credit**
- Write your final answer in the box provided

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### Stress and Strain
\[ \sigma = \frac{F}{A}, \quad \varepsilon = \frac{\Delta L}{L} \]
\[ \Delta L = \frac{FL}{EA}, \quad E = \frac{\sigma}{\varepsilon} \]
\[ FS = \frac{\text{Strength}}{\text{Load}} \]

### Universal Law of Gravitation
\[ F_G = G \frac{m_1 m_2}{r^2}, \quad g = G \frac{M}{r^2} \]
\[ G = 6.674 \times 10^{-11} \text{Nm}^2/\text{kg}^2 \]
\[ G = 6.674 \times 10^{-11} \text{m}^3/\text{kg} \cdot \text{s} \]

### Kepler’s Laws
\[ T^2 = \frac{(2\pi)^2}{GM} \]
\[ a = \frac{r_{\text{max}} + r_{\text{min}}}{2} \]
\[ e = \frac{r_{\text{max}} - r_{\text{min}}}{2a} \]

### Satellites
\[ v = \sqrt{\frac{GM}{r+h}} \]
\[ v_{\text{esc}} = \sqrt{\frac{2GM}{r}} \]
\[ T = \frac{2\pi}{\omega} \]
\[ r_{\text{Earth}} = 6.38 \times 10^6 \text{ m} \]
\[ m_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg} \]

### Uniform Circular Motion
\[ \omega = \sqrt{\frac{v}{r}} \]
\[ a_t = \frac{v^2}{r} \]

### Bernoulli’s Equation
\[ p_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2 \]

### Continuity
\[ v_1 A_1 = v_2 A_2 \]

### Mass Density
\[ \rho = \frac{m}{V} \]

### Weight Density
\[ \gamma = \frac{W}{V} \]

### Stokes’ Law
\[ F_{\text{drag}} = 6\pi \eta r v \]

### Poiseuille’s Equation
\[ Q = \frac{\pi r^4 (p_1 - p_2)}{8\eta L} \]
\[ \eta_{\text{water}} = 1.0 \times 10^{-3} \text{ Pa} \cdot \text{s} \]

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### Fluids
- \( \rho \) – pressure
- \( h \) – height
- \( \rho \) – mass density
- \( v \) – velocity
- \( K \) – empirical constant
- \( A \) – area
- \( d \) – depth
- \( \rho_0 \) – pressure on top of fluid

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### Density of Water
62.4 lb/ft\(^3\) = 1000 kg/m\(^3\)

### Conversions
- 1 ft\(^3\) = 7.48 gal
- 1 m\(^3\) = 1000 L

### Atmospheric Pressure
101.3 kPa
147 psi

### Pressure in a fluid
\[ p = \rho g d + p_0 \]

### Buoyant force
\[ F_B = \rho g V \]

### Lift
\[ L \sim \rho K A v^2 \]
1. (2 pts) A ball is thrown into a pool of water and sinks to the bottom of the pool. What can we say about the ball’s specific gravity?
   a. SG > 1  
   b. SG = 1  
   c. SG < 1  
   d. Not enough information to say

2. (2 pts) For a Linear Elastic material, what does the slope of the line on graph shown represent?
   a. Strain  
   b. Stress  
   c. Elongation  
   d. Force  
   e. Modulus of Elasticity  
   f. Safety Factor

3. (2 pts) Based on the Bernoulli principle, as the velocity of a fluid increases, the pressure of the fluid:
   a. increases  
   b. decreases  
   c. stays the same  
   d. depends on the area

4. (10 pts) We’ve discovered a new planet ($r_p = 7.1 \times 10^6$ m) and sent a satellite to orbit to collect information. The velocity of satellite is 1760 m/s when it is 23,100 km above the planet’s surface. What is the mass of the new planet?
5. (10 pts) EFD has made a new building material called PoliLeeLund metal \((E = 2.3 \times 10^9 \text{ lb/ft}^2)\). How much will a 4 inch X 5 inch and 17 ft long sample of PoliLeeLund shorten if a 6500 lb axial load is applied?

6. (10 pts) If the Argo submarine is taking pictures of the wreckage of the Titanic at 12,000 feet below the surface of the ocean, what is the force on Argo’s window (see picture for details)?
7. (16 pts) An beam is supported by a roller at A and a pin at B as shown. Assume the weight of the beam is negligible. Determine the magnitude of the reaction force at B. A separate, complete FBD is required for full credit.

8. (16 pts) Andrew pulls an 80 lb box up a ramp. When he pulls with a force of 40 lb, the box starts to tip up. What is the y-location of the center of gravity of the box? A separate, complete FBD is required for full credit.
9. (16 pts) An 10 ft x 10 ft x 10 ft underwater hotel room is submerged in the ocean and held in place by a steel cable (US = 270 X 10^3 psi). The engineer designed the cable to have a safety factor of 3.7 with a cross-sectional area of 0.55 in^2. What is the weight of the underwater hotel room?

A separate, complete FBD is required for full credit.

10. (16 pts) The venturi meter (as shown) is measuring the flow of nitrogen gas (γ_nitrogen = 2.341 lb/ft^3). Point 1 has a pipe diameter of 5 inches and a pressure of 11.8 psi. Point 2 has a pipe diameter of 3 inches and a pressure of 10.6 psi. What is the velocity of the nitrogen gas at point 2?