**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

### 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
\[
F_G = G \frac{m_1 m_2}{r^2}
\]
\[
g = G \frac{M}{r^2}
\]
\[
G = 6.674 \times 10^{-11} \text{ Nm}^2/\text{kg}^2
\]

### Kepler's Third Law
\[
\frac{T^2}{a^3} = \frac{(2\pi)^2}{GM}
\]

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

### Bernoulli's Equation
\[
p_1 + \frac{1}{2} \rho v_1^2 + \rho gh_1 = p_2 + \frac{1}{2} \rho v_2^2 + \rho gh_2
\]

### Continuity
\[
v_1A_1 = v_2A_2
\]

### Density of Water
\[
62.4 \text{ lb/ft}^3 = 1000 \text{ kg/m}^3
\]

### Atmospheric Pressure
\[
101.3 \text{ kPa}
\]
\[
14.7 \text{ psi}
\]

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

### Buoyant force
\[
F_B = \rho gV
\]

### 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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1. (2 pts) Donnie Tyndall is standing on the end of a diving board. Which is true about the forces exerted on the diving board?
   a. $F_A$ is down, $F_B$ is up, $F_B > F_A$
   b. $F_A$ is down, $F_B$ is up, $F_A > F_B$
   c. Both forces are up, $F_A > F_B$
   d. Both forces are up, $F_B > F_A$

2. (2 pts) An insulated aluminum electrical wire holds up an electrical fixture. What is the same for both the aluminum and insulation?
   a. Stress
   b. Factor of Safety
   c. Deformation
   d. Force
   e. Area
   f. Modulus of Elasticity

3. (2 pts) Two types of flow were discussed, laminar and ____________________.

4. (2 pts) The water pressure on a dam varies with:
   a. the length of the lake behind the dam
   b. the depth of the water
   c. both the length and the depth
   d. neither the length or depth

5. (2 pts) A pitot tube is used to measure:
   a. elevation
   b. stress
   c. velocity
   d. viscosity

6. (6 pts) Determine the pressure difference required to pump 0.3 L/s of chocolate syrup through a 2 m long, 2.5 cm radius pipe. ($\eta_{chocolate\ syrup} = 17 \text{ Pa}\cdot\text{s}$)
7. (14 pts) Determine the force in the cable. **A separate, complete FBD is required for full credit.**

8. (14 pts) Determine the force, $P$, required to tip the box up (clockwise). **A separate, complete FBD is required for full credit.**
9. (14 pts) A 2800 pound load is applied to an aluminum circular rod. Determine the minimum required diameter of the aluminum rod to the nearest 1/8 of an inch so that there is at least a factor of safety of 3. The ultimate strength of the aluminum is 40,000 psi.

10. (14 pts) Halley’s comet orbits the sun and has a period of 75.3 years. The perihelion (closest the comet comes to the sun) is 0.59 AU. Determine the eccentricity of the orbit of Halley’s comet. \(1 \text{ AU} = 1 \text{ astronomical unit} = \text{distance from earth to sun} = 1.496\times10^{11} \text{ m}\).
11. (14 pts) A 25 pound weight rests on a scale in the bottom of a water tank. The scale reads 6 pounds. The weight is also held up by a 4 pound force. Determine the volume of the 25 pound weight. A separate, complete FBD is required for full credit.

12. (14 pts) Water exits a pump through a 0.034m$^2$ pipe at a pressure of 700 kPa. The water is pumped up to a heat exchanger that has a 0.020 m$^2$ pipe. The heat exchanger requires a pressure of 400 kPa and a flow rate of 0.5 m$^3$/sec. What is the maximum height the heat exchanger can be placed above the pump and still meet the design requirements?