uniform circular motion
\[ a_n = \frac{v^2}{\rho} \]
\[ \omega = \frac{\Delta s}{T} \]
\[ \omega = \frac{v}{\rho} \]
\[ T = \frac{2\pi}{f} \]
\[ f = \frac{1}{T} \]
\[ \Delta s = \rho \Delta \phi \]
\[ \Delta \phi = \frac{\omega}{2\pi} \]

density of water
\[ \rho = 1000 \text{ kg/m}^3 \]

Stokes' law
\[ F_d = \frac{1}{8} \pi \eta L \frac{v^2}{\rho} \]
\[ \eta \text{ – viscosity} \]
\[ L \text{ – characteristic length} \]
\[ v \text{ – velocity} \]
\[ \rho \text{ – mass density} \]
\[ R \text{ – sphere radius} \]

Universal law of gravitation
\[ F_G = \frac{G m_1 m_2}{r^2} \]
\[ G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \]

Kepler's third law
\[ \frac{T^2}{R^3} = C \]

Satellites
\[ v = \sqrt{\frac{\sqrt{Gm_1}}{r} + h} \]
\[ v_{esc} = \sqrt{\frac{2Gm_1}{r}} \]
\[ U = -\frac{GmM}{r} \]
\[ r_{Earth} = 6.378 \times 10^6 \text{ m} \]
\[ m_{Earth} = 5.976 \times 10^{24} \text{ kg} \]

Conservation of mass (continuity)
\[ \frac{A_1 v_1}{A_2} = \frac{A_2 v_2}{A_1} \]

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

Lift
\[ L = \rho K A v^2 \]

Pressure in a fluid
\[ p = \rho gd + p_0 \]

Stress and strain
\[ \sigma = \frac{F}{A} \]
\[ \epsilon = \frac{\Delta L}{L} \]

Factor of safety (FS)
\[ FS = \frac{\text{Strength}}{\text{Load}} \]

Fluids
\[ p \text{ – pressure} \]
\[ h \text{ – height} \]
\[ \rho \text{ – mass density} \]
\[ v \text{ – velocity} \]
\[ K \text{ – empirical constant} \]
\[ A \text{ – area} \]
\[ d \text{ – depth} \]
\[ p_0 \text{ – pressure on top of fluid} \]

Atmospheric pressure
\[ 101.3 \text{ kPa} \]
\[ 14.7 \text{ psi} \]

Conversions
\[ 1 \text{ ft}^3 = 7.48 \text{ gal} \]
\[ 1 \text{ m}^3 = 1000 \text{ L} \]

Reynolds number
\[ Re = \frac{v L}{\eta} \]

Poiseuille's equation
\[ Q = \frac{\pi r^4 (P_1 - P_2)}{8 \eta L} \]
\[ \eta \text{ – viscosity} \]
\[ L \text{ – characteristic length} \]
\[ v \text{ – velocity} \]
\[ \rho \text{ – mass density} \]
\[ R \text{ – sphere radius} \]
5. (14 pts) This symmetrical accoya bridge weighs 2500 lb and spans a distance of 30 feet. It will be analyzed as if it had a pin joint at the left support, and a roller support on the right. A sensor shows that the left support has a vertical load of 1350 lbs with a 500 lb unicyclist on the bridge. How far is the cyclist from the left support? A separate, complete FBD is required for full credit.

6. (14 pts) The Colts' 2010 Lombardi trophy will weigh 7 lb. What force P is required to make it tip to the right. The center of mass of the $12,500 sterling silver trophy is shown right above the NFL logo. A separate, complete FBD is required for full credit.

7. (14 pts) A thin, square (10 mm x 10 mm) aluminum rod that is 2.5 meters long must support a tension load with a factor of safety of 3. How much does it elongate under its maximum allowable load? Aluminum: Young's modulus = 70 GPa, Yield Strength = 414 MPa

8. (14 pts) What is the period of a satellite that orbits the earth at a constant altitude of 2000 km?
9. (14 pts) Professor Schleter’s golf ball sinks into the ocean next to the 9th hole at Pebble Beach. What is its theoretical terminal velocity based on Stokes’ Law?

- Mass of the ball = 0.046 kg
- Volume of the ball = 4.46 x 10^-5 m^3
- Radius of the ball = 0.022 m
- Density of salt water = 1030 kg/m^3
- Viscosity of salt water = 1.08 x 10^-3 Pa · s

10. (14 pts) Dr. Arel buys a pressurized water tank and installs it in Estabrook 205. She hooks a hose to it and runs the hose down to Estabrook 111. The end of the hose is 18 feet below the water level in the tank and has a 1/4 inch diameter nozzle. Dr. Arel pumps the tank to a pressure of 80 psi (gauge). What is the volume flow rate (gal/s) of the water coming out of the nozzle?