1. The Saturn V first stage (the S-IC) burned fuel/oxidizer at the rate of $1.5 \times 10^4$ kg/s with exhaust speed 2600 m/s. The mass of the fully-loaded S-IC was $2.3 \times 10^6$ kg, essentially all fuel.

(a) Calculate the S-IC thrust.

(b) Calculate the initial vertical acceleration at launch, when the total mass of the Saturn V assembly is $3.0 \times 10^6$ kg.

(c) At the end of the S-IC burn, the Saturn V is at an altitude of 120 km. Calculate its speed, neglecting air resistance (but including gravity).
2. A uniform rod of mass $M$ and length $L$, pivoted at the bottom, is released from rest in the vertical position and falls down.

(a) Find an expression for the rotation speed $\omega$ when the rod is horizontal.

(b) Find an expression for the angular acceleration $\alpha$ when the rod is horizontal.

(c) Find the horizontal and vertical components of the force on the rod at the pivot, $F_h$ and $F_v$, and indicate their directions on the diagram.
3. Halley's comet has an elliptical orbit with a minimum distance from the Sun, or perihelion, of 0.570 AU, and period of 75.6 years.

(a) Calculate the maximum distance, or aphelion, of Halley's comet from the Sun.

(b) Calculate the speed \( v_{per} \) of the comet at perihelion.

(c) Calculate the speed \( v_{ap} \) of the comet at aphelion.
4. A horizontal plank of mass $M$ and length $L$ is pivoted at one end. The other end is attached to a vertical spring with force constant $k$. The system is in equilibrium when the plank is horizontal.

(a) Find the torque on the plank as a function of angle $\theta$. Use the hinge as the pivot.

(b) Derive the equation of motion relating the angle $\theta$ to the angular acceleration $\ddot{\theta}$.

(c) Determine the frequency $\omega$ of small-angle oscillations.
5. A stream of water flows steadily from a faucet head. At the head, the stream has diameter 0.960 cm. The stream fills a 125 ml container in 16.3 s.

(a) Determine the speed of the stream at the faucet head.

(b) Calculate the speed of the stream 13.0 cm below the faucet head.

(c) Calculate the diameter of the stream 13.0 cm below the faucet head.