1. Water enters a centrifugal pump axially at a rate of 1.2 m³/s and at a velocity 7 m/s, and leaves in the normal direction along the pump casing, as shown in the figure. Determine the force acting on the shaft in the axial direction. (840N)

2. A lawn sprinkler with three identical arms shown in figure is used to water a garden by rotating in a horizontal plane by the impulse caused by water flow. Water enters the sprinkler along the axis of rotation at a rate of 40 L/s, and leaves the 1.2-cm-diameter nozzles in the tangential direction. The bearing applies a retarding torque of $T_0 = 50$ N.m due to friction at the anticipated operating speeds. For a normal distance of 40 cm between the axis of rotation and the center of the nozzles, determine the angular velocity of the sprinkler shaft. (2740 rpm)

3. Pelton wheel turbines are commonly used in hydroelectric power plants to generate electric power. In these turbines, a high-speed jet at a velocity of $V_j$ impinges on buckets, forcing the wheel to rotate. The buckets reverse the direction of the jet, and the jet leaves the bucket making an angle $\beta$ with the direction of the jet, as shown in the figure. Show that the power by a Pelton wheel of radius $r$ rotating steadily at an angular velocity $\omega$ is $W_{shaft} = \rho \omega r Q (V_j - \omega r)(1 - \cos \beta)$, where $\rho$ is the density and $Q$ is the volumetric flow rate of the fluid. Obtain the numerical value for $\rho = 1000$ kg/m³, $r = 2$ m, $Q = 10$ m³/s, $N = 150$ rpm, $\beta = 160^\circ$ and $V_j = 50$ m/s. (11.3 MW)
4. Oil (specific gravity of 0.88) flows in an inclined pipe at a rate of 141 L/min as shown in figure. If the differential reading in the mercury manometer is 0.9 m, calculate the power that the pump supplies to the oil if head losses are negligible. (264 W)

5. The hydraulic system of the space shuttle consists of two closed reservoirs which are connected by a pipe with a cross-sectional area of 0.002 m$^2$. The pressures in the upper and lower reservoirs are 300 kPa and 600 kPa, respectively. The hydraulic oil with a density of 800 kg/m$^3$ is to be pumped at a volumetric flow rate of 0.005 m$^3$/s from the upper reservoir to the lower one by means of a pump with an efficiency of 75 percent. The elevation difference between the two reservoirs is 6 m. The overall head loss coefficient for the pipe is 10. Determine the power required by the pump, when the space shuttle accelerates upwards with an acceleration of 4g. (597 W)
6. A fluid jet of diameter $D_1$ enters a cascade of moving blades at absolute velocity $V_1$ and angle $\beta_1$, and it leaves at absolute velocity $V_2$ and angle $\beta_2$, as shown in Figure. The blades move at velocity $u$. Derive a formula for the power $P$ delivered to the blades as a function of these parameters. \( \frac{1}{2}m(V_1^2 - V_2^2) \)

7. The pump in Figure creates a 20°C water jet oriented to travel a maximum horizontal distance. System friction head losses are 6.5 m. The jet may be approximated by the trajectory of frictionless particles. What power must be delivered by the pump? \(26.2 \text{ kW} \)