1. The Euler turbine equation for some turbomachines is expressed as \( gH = (U_1V_{0i} - U_2V_{0o}) \). By applying necessary manipulation, derive the following expression from Euler turbine equation

\[
(gH) = \frac{1}{2} \left[ (V_1^2 - V_2^2) + (U_1^2 - U_2^2) - (W_1^2 - W_2^2) \right]
\]

where \( (V_1^2 - V_2^2)/2 \) is the energy transferred due to the change of absolute kinetic energy of the fluid during its passage between the entrance and exit section, \( (U_1^2 - U_2^2)/2 \) is the centrifugal effect due to the centrifugal forces that are developed as the fluid particles move outwards towards the rim of the machine (energy produced by impeller), \( (W_1^2 - W_2^2)/2 \) is the energy transfer due to the change of the relative kinetic energy of the fluid.

2. A radial outflow pump has an impeller with an outside diameter of 305 mm, an inside diameter of 75 mm, and passage height of 49 mm. If the blade inlet angle is 45º to the tangent and the outlet angle is 30º to the tangent, find the flow rate and power needed, ignoring losses and assuming zero inlet whirl for a rotational speed of 1500 rpm. Assume water is pumped with a density of 1000 kg/m³.

3. In a particular centrifugal pump with 5.5m head, the rotational speed is 286 rpm and the meridional velocity along the blades is 2.4 m/s and is constant along the blades. The outlet diameter of the impeller is 0.6m and the blade widths at the outlet and inlet of the rotor are 0.03m and 0.06m, respectively. Assume that there is no inlet swirl and the blade angles are equal to fluid angles.
   a) Calculate the flowrate through the pump
   b) Draw velocity profiles at the inlet and outlet of the impeller
   c) Calculate blade angles at the inlet and outlet of the impeller

4. The net head of an axial flow turbine is 10m and its hydraulic efficiency is 90%. The quantity of water passing through the turbine is 1m³/s. The best description of flow through the impeller may be made if the velocity diagrams at the middle of the blades are considered. The impeller has a hub diameter of 20 cm and a tip diameter of 50 cm. Entry to the runner is shockless (\( \beta_{1v} = \beta_1 \)). The inlet blade angle is \( \beta_{1v} = 90^\circ \). Water leaves the inlet guide vanes with an angle of \( \alpha_i = 15^\circ \) with the tangential direction.
   a) Find meridional (axial) velocity
   b) Find the rotational speed of the impeller
   c) Find the outlet blade angle
5. A centrifugal pump designed to deliver water at 29 lt/s has dimensions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inlet</th>
<th>Outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius r (in.)</td>
<td>3.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Blade width, b (in.)</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Blade angle, β (deg)</td>
<td>25</td>
<td>40</td>
</tr>
</tbody>
</table>

Assuming no inlet whirl,

a) Draw the inlet velocity diagram.
b) Determine the design speed if the entering velocity has no tangential component.
c) Determine the outlet absolute flow angle.
d) Evaluate the theoretical head developed by the pump.
e) Estimate the minimum mechanical power delivered to the pump.