1. The Euler turbine equation for some turbomachines is expressed as \((gH) = (U_1V_{\theta 1} - U_2V_{\theta 2})\). By applying necessary manipulation, derive the following expression from Euler turbine equation

\[
(gH) = \frac{1}{2}[\left(V_{1}^{2} - V_{2}^{2}\right) + \left(U_{1}^{2} - U_{2}^{2}\right) - \left(W_{1}^{2} - W_{2}^{2}\right)]
\]

where \(\frac{1}{2}(V_{1}^{2} - V_{2}^{2})\) is the energy transferred due to the change of absolute kinetic energy of the fluid during its passage between the entrance and exit section, \(\frac{1}{2}(U_{1}^{2} - U_{2}^{2})\) 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), \(\frac{1}{2}(W_{1}^{2} - W_{2}^{2})\) 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 45° to the tangent and the outlet angle is 30° 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. An axial flow fan has tip diameter of 2 m, a hub diameter of 0.8 m, and rotates at 1450 rpm. For the condition of zero inlet whirl estimate the velocity diagrams at the tip section, if the inlet absolute velocity is 55 m/s the air has a density of 1.2 kg/m³ and losses are ignored. Estimate also the fluid power, if \(\Delta p\) is 5 kN/m².
4. 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.

5. Find an expression for the nozzle efficiency in terms of $p_{01}$, $p_{02}$, $p_1$ & $p_2$ for incompressible flows.