Structures, Propulsion, and Control

Objectives
At the end of this problem set, you should be able to:
• Perform a load analysis of a truss
• Select an appropriate material to minimize structural weight
• Describe principles of operation of propellers and gas turbine engines
• Perform a stability analysis of an aircraft design

1. The two-dimensional truss below must carry a load of 5000 lb applied at the joint shown. The truss can be built from steel, aluminum, or titanium, with the material properties shown. The truss bars are solid cylinders and all must have the same radius. Determine which material should be used in the bars to carry this load with a 1.5x safety factor while minimizing total truss weight. Also specify the radius of the truss bars, and the total weight of the truss structure.

![Truss Diagram]

<table>
<thead>
<tr>
<th>Material</th>
<th>Yield Stress (lb/in²)</th>
<th>Density (lb/in³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>55,000</td>
<td>0.28</td>
</tr>
<tr>
<td>Aluminum</td>
<td>83,000</td>
<td>0.09</td>
</tr>
<tr>
<td>Titanium</td>
<td>140,000</td>
<td>0.16</td>
</tr>
</tbody>
</table>

2. Explain why a variable-pitch propeller is more efficient than a constant-pitch propeller.
3. Briefly explain (using only one or two sentences per element) what is the function of each of the following elements in a turbofan engine:
   - diffuser
   - compressor
   - burner
   - turbine
   - nozzle
   - bypass fan

4. For the aircraft wing/tail configuration below, determine the location of the forward-most and rear-most permissible center-of-gravity locations, $x_{CG}$.

   $W = 1000 \text{ N}$
   $M_{ac} = 100 \text{ Nm}$ (nose down; constant regardless of angle of attack)
   Maximum downward tail force: $L_t = -100 \text{ N}$
   If disturbed slightly from the trim condition, $L_t$ changes by $1/10$ the amount that $L$ changes.