Exam Overview:
- The exam consists of 8 questions worth 12 points each (you get 4 free points).
- The two problems on each page are related. You can use any and all the work that you write out for your solution to the first problem for the solution of the second problem on each page. You DO NOT need to redraw Coordinate Systems, FBDs, etc.
- Each problem will be graded on 0, 3, 6, 8, 10, 12 scale.
- Material properties for selected materials as well as various constants, planetary data, and math formulas are provided below.

Be sure to:
- Show all of your work.
- Include units for all answers.
- Include the correct number of significant digits.
- Include directions for all vectors.
- Write your final answer in the box provided.

Hints:
- Stay calm.
- Glance over all problems, tackle the “easy” ones first.
- Use reasonableness to guide you.
- Allow yourself an average of 6 minutes per problem (12 minutes per page).

<table>
<thead>
<tr>
<th>Material</th>
<th>E</th>
<th>Ultimate Strength</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>210,000 MN/m²</td>
<td>600 MN/m²</td>
<td>8030 kg/m³</td>
</tr>
<tr>
<td>Pure Aluminum</td>
<td>73,000 MN/m²</td>
<td>70 MN/m²</td>
<td>2740 kg/m³</td>
</tr>
<tr>
<td>Titanium Alloy</td>
<td>102,000 MN/m²</td>
<td>1400 MN/m²</td>
<td>4850 kg/m³</td>
</tr>
<tr>
<td>Glass</td>
<td>70,000 MN/m²</td>
<td>170 MN/m²</td>
<td>2400-2800 kg/m³</td>
</tr>
</tbody>
</table>

Constants:
- \( g = 9.81 \text{ m/s}^2 = 32.2 \text{ ft/s}^2 \)
- \( G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2 \)
- Earth: Mass = 5.97 x 10^{24} kg, Radius = 6.38 x 10^6 m
- Moon: Mass = 7.35 x 10^{22} kg, Radius = 1.74 x 10^6 m
- Sun: Mass = 1.99 x 10^{30} kg, Radius = 6.96 x 10^8 m
- Earth-moon distance = 3.84 x 10^8 m
- Earth-sun distance = 1.496 x 10^{11} m

Area, Volume, and Trig Formulas:
- Area of a circle: \( \pi r^2 \)
- Volume of a sphere: \( \frac{4}{3} \pi r^3 \)
- Law of sines: \( \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c} \)
- Law of cosines: \( c^2 = a^2 + b^2 - 2ab \cos C \)