Point totals are given for each part of the question.
If you run out of room, continue writing on the back of the same page. If you do so, make a note on the front part of the page!
Note: You must solve the problem following the instructions given in the problem. Correct answers alone will not receive full credit.

Partial Credit:
→ Show Your Work! Answers written with no explanation will not receive full credit.
→ You can receive credit for describing the method you would use to solve a problem, even if you missed an earlier part.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Credit</th>
<th>Max. Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
\[
\vec{r} \cdot \hat{z} = rs \cos \theta \\
\vec{r} \times \hat{z} = \text{det} \begin{bmatrix} \hat{x} & \hat{y} & \hat{z} \\ r_x & r_y & r_z \\ s_x & s_y & s_z \end{bmatrix} \\
\vec{F} = m\ddot{\vec{r}} \\
\text{Constant } a(t) = x_0 + v_0t + t^2/2 \\
v(t) = v_0 + at; \quad v_f^2 - v_i^2 = 2a\Delta x \\
\vec{F} = -f(v)\hat{v} \\
f(v) = b\nu + c\nu^2 = \beta D
\]
\[(\ddot{R} - \omega^2 \ddot{M}) \dddot{a} = 0 \quad \ddot{\phi} + 2\beta \dot{\phi} + \omega_0^2 \sin \phi = \gamma \omega_0^2 \cos(\omega t), \text{ with } \gamma = \frac{F_0}{mg}, \text{ and } F(t) = F_0 \cos(\omega t)\]

\[\ddot{q}_i = \frac{\partial \mathcal{H}}{\partial p_i} \text{ and } \dot{p}_i = -\frac{\partial \mathcal{H}}{\partial q_i} \quad [i = 1, \ldots, n]\]

\[G(t, t') = \begin{cases} \frac{e^{-\beta(t-t') \sin(\omega_0(t-t'))}}{m \omega_1} & \text{for } t \geq t' \\ 0 & \text{for } t < t' \end{cases} \quad x(t) = \int_{-\infty}^{t} F(t') G(t, t') dt'\]

Binomial expansion for \(x \ll 1\): 
\[(1 + x)^n \equiv 1 + nx + \frac{n(n-1)}{2}x^2\]

\[
\frac{1}{1+x} = 1 - x + x^2 - x^3 + \cdots \quad (x < 1)
\]