Exam 1 Review

Exam 1 will cover the following topics:
- Chapter 2 – One-Dimensional Motion
- Chapter 4 – Projectile Motion
- Chapter 5,6 – Newton’s 2nd Law

There will be 6 problems:
- 4 Problem Set type problems
- 1 PLC Ranking question
- 1 Conceptual type question

Chapter 2: Motion along a Straight Line

Conceptual Type Questions
1. When the velocity is constant, can the average velocity over any time interval differ from the instantaneous velocity at an instant? If so, give an example; if not, explain why.
2. Can the average velocity of a particle moving along an axis ever be \((v_0 + v)/2\) if the acceleration is not uniform? Prove your answer with graphs.
3. Can an object have zero velocity and still be accelerating? Can an object have a constant velocity and still have a varying speed? In each case, give an example if your answer is yes; explain why if your answer is no.
4. Can the velocity of an object reverse direction when its acceleration is constant? If so, give an example; if not, explain why.
5. Can an object be increasing in speed as its acceleration decreases? If so, give an example; if not, explain why.
6. On a planet where the value of \(g\) is one-half the value of Earth, an object is dropped from rest and falls to the ground. How is the time needed for it to reach the ground from rest related to the time required to fall the same distance on Earth?

Calculation Type Problems
1. One-Dimensional Kinematics

\[
\Delta x = \frac{1}{2}(v_x + v_{x0})t \\
x = x_0 + v_{x0}t + \frac{1}{2}a_xt^2 \\
v_x = v_{x0} + a_xt \\
v_x^2 = v_{x0}^2 + 2a_x\Delta x
\]

\[
\Delta y = \frac{1}{2}(v_y + v_{y0})t \\
v_y = v_{y0} - gt \\
y = y_0 + v_{y0}t - \frac{1}{2}gt^2 \\
v_y^2 = v_{y0}^2 - 2g\Delta y
\]

Chapter 3: Vectors

Calculation Type Problems

\[
a_x = a \cos \theta \\
a_y = a \sin \theta \\
a = \sqrt{a_x^2 + a_y^2} \\
\tan \theta = \frac{a_y}{a_x}
\]

\[
\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k} \\
\vec{a} \cdot \vec{b} = ab \cos \phi
\]

\[
\vec{a} \cdot \vec{b} = (a_x \hat{i} + a_y \hat{j} + a_z \hat{k}) \cdot (b_x \hat{i} + b_y \hat{j} + b_z \hat{k}) = a_x b_x + a_y b_y + a_z b_z
\]

Chapter 4: Projectile Motion

Conceptual Type Questions
1. Why are the horizontal and vertical components independent of each other in projectile motion?
2. What is the velocity of a projectile at the peak of its trajectory?
3. If a rock is dropped from the top of a sailboat’s mast, will it hit the deck at the same point regardless of whether the boat is at rest or in motion at constant velocity?
4. What physical factors \((v_{ox}\) and \(v_{oy}\)) are important for an athlete doing the long jump? What about the high jump?
5. In terms of \(v_{oy}\), when is the projectile past the peak height?
6. Why does a projectile have the same speed twice along its trajectory?
7. When is the range equation applicable? When the maximum height equation applicable?
8. A shot put is thrown from above the athlete’s shoulder level. The launch angle that will produce the longest range is less than 45\(^0\); that is, a flatter trajectory has a longer range. Explain why.
9. A car rounds a curve at a steady 50 km/h. If it rounds the same curve at a steady 70 km/h, will its acceleration be any different? Explain.

**Calculation Type Problems**

**1. Reasoning Strategy for Applying Projectile Equations**

Step 1. Make a drawing of the situation and interpret the question. Remember the directions of motion: upward motion is positive and downward motion is negative.

Step 2. Write down the velocity into its x- and y-components: \(v_{0x} = v_0 \cos \theta\) and \(v_{oy} = v_0 \sin \theta\).

Step 3. Create two Data Tables for each component of motion.

<table>
<thead>
<tr>
<th>(\Delta x)</th>
<th>(v_x = v_{ox})</th>
<th>(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(\Delta y)</th>
<th>(v_y)</th>
<th>(v_{oy})</th>
<th>(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note the changes that are made, I did not include the acceleration into either of these data tables since the values are ALWAYS known: \(a_x = 0\) and \(a_y = -g\).

Step 4. Use the kinematics table to organize your thinking into selecting the correct equation

\[
\begin{align*}
\Delta x &= v_{ox} \Delta t \quad \Delta y = v_{oy} \Delta t - \frac{1}{2} g \Delta t^2 \\
\end{align*}
\]

**2. Circular Motion**

\[
v = \frac{2\pi}{T} \quad \text{and} \quad a = \frac{v^2}{r}
\]

**Chapter 5.6: Newton’s Laws**

**Conceptual Type Questions**

1. If you are squatting down (such as when you are examining the books on the bottom shelf in a library or bookstore) and suddenly get up, you can temporarily feel light-headed. What do Newton’s laws of motion have to say about why this happens?
2. In a head-on collision, passengers not wearing seat belts can be thrown through the windshield. Use Newton’s laws of motion to explain why this happens?
3. When you fly in an airplane at night in smooth air, there is no sensation of motion, even though the plane may be moving at 800 km/h (500 mi/h). Explain why is this in terms of Newton’s laws?
4. A clothesline is hung between two poles. No matter how tightly the line stretched, it always sags a little at the center. Explain why.
5. A passenger in a moving bus with no windows notices that a ball that has been at rest in the aisle suddenly starts to move toward the rear of the bus. Think of two different possible explanations, and devise a way to decide which is correct.
6. Why does the acceleration of a freely falling object not depend on the weight of the object?

7. Two teams are having a tug-of-war; explain what the winning team must do?

8. If your hands are wet and no towel is handy, you can remove some of the excess water by shaking them. Why does this get rid of the water?

**Reasoning Strategy for Applying Newton’s 2nd Law**

**Step 0:** Is the object in equilibrium or nonequilibrium?

\[
\begin{cases}
\text{If equilibrium} & \Rightarrow \sum F = ma = 0 \\
\text{If nonequilibrium} & \Rightarrow \sum F = ma \neq 0
\end{cases}
\]

**Step 1:** Sketch the situation and draw a Free-Body Diagram.

- Free-Body Diagram (FBD)
  - isolate the object and reduce to a center-of-mass point
  - identify all the forces acting on this point
  - choose a coordinate system convenient to you

**Step 2:** Breakup all forces into its components along the x- and y-axes, and sum the components. The following force table may be convenient.

<table>
<thead>
<tr>
<th>Force</th>
<th>x-component</th>
<th>y-component</th>
</tr>
</thead>
<tbody>
<tr>
<td>(F_1)</td>
<td>(F_{1x})</td>
<td>(F_{1y})</td>
</tr>
<tr>
<td>(F_2)</td>
<td>(F_{2x})</td>
<td>(F_{2y})</td>
</tr>
<tr>
<td>(F_3)</td>
<td>(F_{3x})</td>
<td>(F_{3y})</td>
</tr>
</tbody>
</table>

\[\sum F_x = F_{1x} + F_{2x} + F_{3x} \quad \sum F_y = F_{1y} + F_{2y} + F_{3y}\]

**Step 3:** Apply Newton’s 2nd law \((\sum F_x = ma_x \text{ and } \sum F_y = ma_y)\), pick the acceleration direction as positive, and solve the two equations for the desired unknown quantities.

**1. Frictional Forces**

\[
\begin{cases}
\text{friction, max: } f_{l,\text{max}} = \mu_l N \\
\text{friction, normal: } f_n = \mu_N N
\end{cases}
\]

\[
\begin{align*}
N_{\text{flat}} &= mg \pm F_y \quad \text{(flat surfaces)} \\
N_{\text{incline}} &= mg \cos \theta \pm F_y \quad \text{(incline surfaces)} \\
N_{\text{wall}} &= F_x \quad \text{(wall surfaces)}
\end{align*}
\]

**2. Centripetal Forces**

\[F_{\text{net}} = ma_c \Rightarrow F_{\text{centripetal}} = \frac{mv^2}{r}\]

**3. Newton’s Condition on Circular Motion**

\[a_c = g \Rightarrow v = \sqrt{rg}\]