Module 1 Exam Review

1. A projectile is fired from a cannon at a 30-degree angle with the ground and an initial velocity of 30 m/s. Assuming no air resistance, but g downward, calculate the time it will spend in the air.

Name: Peter Fox
Date: Not as often as I'd like to, sadly.

FoxTrot
BILL AMEND

There's up, everyone. Please pass your tests forward.

Doubler should not take physics.

Quesцион для моi: "A" for Tamillas. Are me, Mr. Fox?
What if I told you there were only 5 different types of problems on this exam?
Data Variation

Things you need to determine:

- Sample vs. Population
  - Keywords?
- Sample Size
- Significant Figures
- Units

You need this on your equation sheet:

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i
\]

Data variation

- Variance
  \[
  \sigma^2 = \frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})^2
  \]

- Standard deviation
  \[
  \sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})^2}
  \]

- Coefficient of variation
  \[
  CV = \frac{\sigma}{\bar{x}}
  \]

- Sample
  \[
  s^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2
  \]

- Sample
  \[
  s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}
  \]

- Sample
  \[
  CV = \frac{s}{\bar{x}}
  \]
2) (15 pts) Kaylie and Matthew are interested in determining some statistics related to the height of all the EF 157 students. One day during recitation they randomly pick a table of four students and measure their heights. The results are 67.0, 61.0, 69.0, and 71.0 inches. Kaylie and Matthew would like your help, and they ask that you determine

a) the median

b) the mean

c) the standard deviation

d) and coefficient of variation

of the heights of the entire EF 157 class based on their data.

They ask that you show ALL base equations and work, not just the final answers, in order to get full credit.
Final Exam Review

1. Stats

a) \( \bar{x} = \frac{67 + 69}{2} = 68 \) in

b) \( \bar{x} = \left( \frac{1}{n} \right) \sum x = \left( \frac{1}{4} \right)(67 + 61 + 17 + 69) = 67 \) in

c) \( s = \sqrt{\frac{1}{n-1} \sum (x - \bar{x})^2} = \sqrt{\frac{1}{4-1} \left[ (67-67)^2 + (61-67)^2 + (17-67)^2 + (69-67)^2 \right]} = \sqrt{18.66} = 4.32 \) in

d) \( se = \frac{s}{\bar{x}} = \frac{4.32}{67} \) in = 0.065 in
1D Kinematics

Things you need to determine:

- Is the motion in 1D?
- How does my coordinate system need to be drawn?
- What base equations do I need to use?
- Graphing/Graphing Scales
- Significant Figures
- Units

You need this on your equation sheet:

Maybe geometry? Because I always forget the area of a triangle???

\[
\begin{align*}
  s &= \text{position at time } t \\
  v &= \frac{ds}{dt} = \text{velocity at time } t \\
  a &= \frac{dv}{dt} = \text{acceleration at time } t \\
  v_{avg} &= \frac{\Delta s}{\Delta t} = \frac{s_2 - s_1}{t_2 - t_1} \\
  a_{avg} &= \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} \\
  s &= s_o + v_o t + (a_c t^2)/2 \\
  v &= v_o + a_c t \\
  v^2 &= v_o^2 + 2a_c(s - s_o)
\end{align*}
\]
16. (20 pts) A person on horseback starts at $x = 5.0 \text{ m}$ at $t = 0.0 \text{ s}$ and moves along a straight line according to the velocity-time ($v$-$t$) graph shown at right.

a) Construct the acceleration-time ($a$-$t$) graph.

b) What was the total distance traversed by the person and the horse?

c) What is the final position of the person and the horse?
Final Exam Review

1.0 Kinematics

\[ a = \frac{\Delta v}{\Delta t} \]

\( t: 0 - 10 \) s

\[ a = \frac{(0 - (-3)) \text{ m/s}}{(10 - 0) \text{ s}} = \frac{3 \text{ m/s}}{10 \text{ s}} = 0.3 \text{ m/s}^2 \]

\( t: 10 - 15 \) s

\[ a = \frac{(6 - 0) \text{ m/s}}{(15 - 10) \text{ s}} = \frac{6 \text{ m/s}}{5 \text{ s}} = 1.2 \text{ m/s}^2 \]

\( t: 15 - 25 \) s

\[ a = \frac{(0 - 6) \text{ m/s}}{(25 - 15) \text{ s}} = \frac{-6 \text{ m/s}}{10 \text{ s}} = -0.6 \text{ m/s}^2 \]
b) distance traveled on \( v \) vs time graph is absolute value of area.

0-10 sec:
\[
\text{Area of triangle } = \left(\frac{1}{2}\right)(3 \text{ m/s})(10 \text{ s}) = 15 \text{ m}
\]

10-25 sec:
\[
\text{Area of triangle } = \left(\frac{1}{2}\right)(6 \text{ m/s})(25-10) = 45 \text{ m}
\]

Total distance = (15 + 45) m = 60 m

C) final position is area under graph of \( v \) vs time & below \( x \)-axis is negative.

Using areas calculated above
\[
\begin{align*}
\text{Initial position } S_0 & = 6 \text{ m} - 15 \text{ m} + 45 \text{ m} = 35 \text{ m}
\end{align*}
\]
Vector Notation

Things you need to determine:

- Is it a vector?
  - Resultants v. Vector?
- How does my coordinate system need to be drawn?
  - Is it appropriate?
- What form should my vector be in?
- Significant Figures
- Units

You need this on your equation sheet:

- Trigonometry Laws

\[
\begin{align*}
\vec{r}_{B/A} &= \vec{r}_B - \vec{r}_A \\
\vec{v}_{B/A} &= \vec{v}_B - \vec{v}_A \\
\vec{a}_{B/A} &= \vec{a}_B - \vec{a}_A \\
|\vec{v}| &= \sqrt{v_x^2 + v_y^2}
\end{align*}
\]
4. The current of a river causes a floating ball B to move a constant speed of 6.7 ft/s due south. Additionally, a wind causes the ball to move a constant speed of 3.1 ft/s on a bearing of 35° east of north.

a) Determine the velocity of the ball with respect to Observer A who is standing still on the bank of the river.

b) Determine the velocity of the ball with respect to Observer C who is walking over a bridge due west at 4.1 ft/s.
\[ V_{\text{current}} = -6.7 \text{ ft/s} \hat{z} \]

\[ V_{\text{wind}} = 3.1 \text{ ft/s} \left( \sin 35^\circ \hat{x} + \cos 35^\circ \hat{y} \right) \]

\[ = (1.778 \hat{x} + 2.539 \hat{y}) \text{ ft/s} \]

a) \[ V_{B/A} = V_{B/\text{ground}} = V_{\text{current}} + V_{\text{wind}} \]

\[ = -6.7 \hat{z} \text{ ft/s} + (1.778 \hat{x} + 2.539 \hat{y}) \text{ ft/s} \]

\[ = (1.778 \hat{x} - 4.161 \hat{z}) \text{ ft/s} = (1.8 \hat{x} - 4.2 \hat{z}) \text{ ft/s} \]

b) \[ V_{B/C} = V_{B/A} - V_{C/A} = V_{B/\text{ground}} - V_{C/\text{ground}} \]

\[ = (1.778 \hat{x} - 4.161 \hat{z}) \text{ ft/s} - (-4.1 \hat{x} \text{ ft/s}) \]

\[ = (5.878 \hat{x} - 4.161 \hat{z}) \text{ ft/s} = (5.9 \hat{x} - 4.2 \hat{z}) \text{ ft/s} \]
2D Kinematics/Projectile Motion

Things you need to determine:

- What are my given values?
  - In both directions...
- What are my initial conditions?
  - *hint hint datum and C.S.*
- What can I substitute and solve?
- Significant Figures
- Units

You need this on your equation sheet:

\[
\begin{align*}
\vec{r}(t) &= x(t) \hat{i} + y(t) \hat{j} \\
\vec{v}(t) &= \left( \frac{dx}{dt} \right) \hat{i} + \left( \frac{dy}{dt} \right) \hat{j} \\
\vec{a}(t) &= \left( \frac{d^2x}{dt^2} \right) \hat{i} + \left( \frac{d^2y}{dt^2} \right) \hat{j}
\end{align*}
\]
3) (20 pts) The archerfish hunts by dislodging an unsuspecting insect from its resting place with a stream of water expelled from the fish's mouth. Suppose the archerfish squirts water with an \textit{initial speed} of 2.30 m/s at an \textit{angle} of 19.5\degree \textit{above the horizontal}. When the stream of water reaches a beetle on a leaf at \textit{height} \( h \) above the water's surface, it is moving \textit{horizontally}.

a) How much \textit{time} does the beetle have to react?

b) What is the \textit{height} \( h \) of the beetle?

c) What is the \textit{horizontal distance} \( d \) between the fish and the beetle when the water is launched?
(a) \( V_0 = 2.30 \text{ m/s} \)
\[
V_{x0} = 2.30 \text{ m/s} \cos(19.5°) = 2.168 \text{ m/s}
\]
\[
V_{y0} = 2.30 \text{ m/s} \sin(19.5°) = 0.7678 \text{ m/s}
\]

At max height, \( V_y = 0 \)
\[
\Rightarrow V_{y0} = V_y - gt
\]

(b) the beetle, again \( V_y = 0 \), \( y = 0 \)
\[
y = y_0 + V_{y0}t - \frac{1}{2}gt^2
\]
\[
h = 0 + 0.7678 \text{ m/s} \times (0.0783 \text{ s}) - \frac{1}{2} (9.81 \text{ m/s}^2) (0.0783 \text{ s})^2
\]
\[
h = 0.0300 \text{ m} \quad \text{or} \quad 3.00 \text{ cm} \quad \text{or} \quad 30.0 \text{ mm}
\]

(c) horizontal distance
\[
x = x_0 + V_{x0}t
\]
\[
d = 2.168 \text{ m/s} \times (0.0783 \text{ s}) = 0.1697 \text{ m} \quad \Rightarrow \quad 0.170 \text{ m} \quad \text{or} \quad 17.0 \text{ cm}
\]
Pulleys

Things you need to determine:

- Coordinate System
- Define “knowns”
- Find Lengths using “knowns”
- KINEMATICS LADDER
- Significant Figures
- Units

You need this on your equation sheet:

- Maybe an example problem?

\[
\vec{r}(t) = x(t) \hat{i} + y(t) \hat{j} \\
\vec{v}(t) = \left( \frac{dx}{dt} \right) \hat{i} + \left( \frac{dy}{dt} \right) \hat{j} \\
\vec{a}(t) = \left( \frac{d^2x}{dt^2} \right) \hat{i} + \left( \frac{d^2y}{dt^2} \right) \hat{j}
\]
1) (15 pts) At $t = 0.00$ s, Blocks A and B are released from rest. Block B experiences a constant downwards acceleration of 0.123 ft/s².

a) What is the **acceleration of Block A** when $t > 0.00$ s?

b) What is the **velocity of Block A** at $t = 35.0$ s?
a) \[ \Delta L_1 = -\Delta X_A \]
\[ \Delta L_2 = -\Delta X_A \]
\[ \Delta L_3 = -\Delta X_A \]
\[ \Delta L_4 = -\Delta Y_B \]
\[ \sum = 0 \rightarrow -3 \Delta X_A - \Delta Y_B = 0 \]
\[ \Delta X_A = -\frac{1}{3} \Delta Y_B \]
\[ V_{AX} = -\frac{1}{3} V_{BY} \]
\[ a_{AX} = -\frac{1}{3} a_{BY} \]
\[ = -\frac{1}{3} (-0.123 \text{ ft/s}^2) = 0.04100 \text{ ft/s}^2 \]

\[ a_A = +0.0410 \text{ ft/s}^2 \hat{c} \]

b) \[ V_{AX} = V_{AX0} + a_{AX} t \]
\[ = (+0.04100 \text{ ft/s}^2)(35 \text{ s}) = +1.435 \text{ ft/s} \]

\[ V_A = +1.44 \text{ ft/s} \hat{c} \]
5. (2 pt) You drive from home to Zeanah at a constant speed of 20 mph and immediately turn around and drive back home at a constant speed of 40 mph. What is your average speed over the entire trip?

<table>
<thead>
<tr>
<th>Speed</th>
<th>0 mph</th>
<th>&gt; 20 mph, but &lt; 30 mph</th>
<th>30 mph</th>
<th>&gt; 30 mph, but &lt; 40 mph</th>
<th>Cannot determine from the given information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

8. (2 pt) Standing on top of Zeanah, you drop one rock directly downward and your friend simultaneously throws an identical rock horizontally from the exact same height. Assuming they both land at a point at the same height, which rock will be traveling faster when it hits the ground? Ignore air resistance.

<table>
<thead>
<tr>
<th>Rock</th>
<th>The dropped rock</th>
<th>The thrown rock</th>
<th>Neither. The speeds will be the same</th>
<th>Cannot determine from the given information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
(20 pts) An Air Force E-3 airborne air traffic control aircraft flies at a constant altitude of 9,850 ft. **Relative to the ground,** it has a speed of 415 mph (**miles per hour**) at a compass heading of 25.0° south of east. It detects an F-16 fighter jet that is flying at the same altitude. **Relative to the E-3,** the F-16 is travelling at a speed of 1530 kph (**kilometers per hour**) at a compass heading of 88.0° north of east (both the magnitude and direction are relative to the motion of the E-3). Determine the following:

[Image of Air Force E-3]

4) (20 pts) The velocity of an Antares rocket launched from NASA Wallops Flight Facility is described by the following equation for the first 3 minutes after launch from the ground:

\[ v(t) = (-2.26E - 4) t^3 + (6.09E - 2) t^2 + 0.474t \]

where \( v \) is in \( \text{m/s} \) and \( t \) is in seconds. Assume that this rocket moves in a straight line in the vertical direction after take-off.

a) Determine the **acceleration of the rocket** after 145 seconds.

b) Determine the **height of the rocket above the ground** after 145 seconds.

c) If the rocket engine cuts off after 145 seconds, how long would it take to fall back to the ground?

(20 pts) The current of a river causes a floating ball B to move a constant speed of 4.6 mi/hr due south. Additionally, a wind causes the ball to move a constant speed of 3.1 ft/s on a bearing of 35° east of north.

a) Determine the **velocity of the ball with respect to Observer A** who is standing still on the bank of the river.

b) Determine the **velocity of the ball with respect to Observer C** who is walking over a bridge due west at 2.8 mi/hr.
20 pts) The cheetah, *Acinonyx jubatus*, can run at a top speed of 75 MPH (miles per hour). The cheetah starts from rest and reaches its top speed in 4.5 seconds. Assume that its acceleration is constant over the 4.5 seconds.

Global Explorer Loch Ness. Anlowing acceleration second interval. At below the surfacenduring this dive.
(relative to theover this 60.0