1. (12 pts) Bruno Pearl throws a basketball from the luxury boxes of the Summit. The ball hits Lana Kiffin sitting on the other side of the arena. What is the horizontal component of the velocity when it hits Lana? (treat the basketball as an ideal projectile)

\[ \frac{13.7}{5} \]

\[ y_k = x_k \tan \theta - \frac{g}{2v_x^2} x_k^2 \left( 1 + \tan^2 \theta \right) \]

\[ -22 = \frac{44 \tan 33^\circ}{2} - \frac{9.81}{2 \cdot 44} \left( 44 \right)^2 \left( 1 + \tan^2 33^\circ \right) \]

\[ v = 16.34 \text{ ft/s} \]

\[ V_k = V_x \cos 33^\circ = 13.7 \text{ ft/s} \]

Correct equation without calculation error: \( V_0 = V_k \frac{1}{2} \) didn't solve for \( V_x \) (2)

2. (12 pts) Boats A and B start from the same location. Boat A is moving with a velocity of 18 mph 20° E of N. Boat B is moving with a velocity of 11 mph south relative to boat A. How far has boat B travelled after 1.5 hours?

\[ 12.8 \text{ miles} \]

\[ V_A = \frac{18}{\sqrt{2}} \]

\[ V_{B/A} = \frac{18}{2} \]

\[ V_B = V_A + V_{B/A} \]

\[ \text{Components} \]

\[ V_B = 18 \cos 70^\circ + 18 \sin 70^\circ - 11.7 \]

\[ = 6.156 + 5.914 \]

\[ s_B = v_B t \]

\[ |V_B| = \sqrt{6.156^2 + 5.914^2} = 8.537 \text{ mph} \]

\[ s_0 = 9.234 \text{ ft} + 8.073 \text{ ft} = 17.307 \text{ ft} \]

\[ \text{Use 111 miles for V_A} \]

\[ 2(18)(11) \]

\[ 216 \text{ miles} \]
3. (12 pts) Dr. Arzini is driving around the Arc de Triomphe (100 ft radius). She starts from rest and accelerates at a constant rate of 1.3 ft/s². How long does it take for her total acceleration to become 2.75 ft/s²?

\[
a_t = 1.3 \text{ ft/s}^2 \\
a_{tot} = 2.75 \text{ ft/s}^2 \]

\[
a_{tot}^2 = a_t^2 + a_n^2 \\
2.75^2 = 1.3^2 + a_n^2 \\
a_n = 2.423 \text{ ft/s}^2 \\
t = \frac{a_n}{a_t} = 11.97 \text{ sec}
\]

- 2 units
- 2 sig figs
- 1/4 calculus error
- 4 incorrect equations
- 4 \( a_n, a_{tot}\) definitions

4. (12 pts) Zachary is driving a jeep on level ground. The jeep is pulling a trailer full of EF students. The group is accelerating at a rate of 3.50 m/s². The coupling force between the jeep and the trailer is 2500 N. How many students are in the trailer?

<table>
<thead>
<tr>
<th>TRAILER W/ STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 students</td>
</tr>
</tbody>
</table>

![mass jeep and Zach = 1200 kg mass empty trailer = 154 kg mass average student = 80kg](image)

- 2 units
- 2 sig figs
- 1/4 calculus error
- 4 incorrect KCD/FBD
- 4 unknown student

5. (12 pts) Nate (175 lb) rides the EF roller coaster. At the bottom of a 50 ft radius loop a scale on his seat says he weighs 390 lb. What was the speed of the coaster at this point? (FBD = KD required)

\[
N - W = ma_n \\
390 \text{ lb} - 175 \text{ lb} = 175 \text{ lb} \times \frac{390 \text{ lb}}{175 \text{ lb}} \\
a_n = 39.56 \text{ ft/s}^2 \\
v = \sqrt{(50 \text{ ft})(39.56 \text{ ft/s}^2)} = 44.5 \text{ ft/s}
\]

- 4 = read error
- 4 = round up/square root
- 4 = something wrong on 0.5 kg and 0.5 kg terms in eq.
- 8 = incorrect diagrams
- 10 = place all items

6. (12 pts) Shane (72 kg) goes sledding. He accelerates down the hill at 2.44 m/s². What is the coefficient of kinetic friction for the snow? (FBD = KD required)

\[
0.136 \text{ m/s}^2
\]

- 10 = place all items
- 8 = drawings mostly correct
- 10 = incorrect KCD/FBD
- 2 = incorrect \( \mu_k \)
- 4 = incorrect \( \mu_k \) and diagrams correct

\[
F = m \cdot a \]

- 2 units
- 2 sig figs
- 1/4 calculus error
- 4 incorrect KCD/FBD
- 4 unknown student

\[
m = 72 \text{ kg} \\
a = 2.44 \text{ m/s}^2 \\
N - W \sin 22 = 0 \\
F = 72(9.81 \sin 22) - 72(9.81) \\
F = 88.91 \text{ N} \\
N = 72(9.81) \cos 22 \\
N = 654.9 \text{ N} \\
F = \mu_k N \\
\mu_k = \frac{88.91}{654.9} = 0.136
\]
7. (4 pts) A projectile has a speed of 5 ft/s at its highest point. If it was launched at an angle of 60° above horizontal what was its launch speed?

\[ v_x = \frac{5 \text{ ft/s}}{\cos 60°} \]

8. (4 pts) A person weighs 200 lb on Earth. What is the mass of the person on the moon where the acceleration due to gravity is 5.37 ft/s²?

\[ m = \frac{W}{g} = \frac{200 \text{ lb}}{32.2 \text{ ft/s}^2} = 6.21 \text{ slugs} \]

9. (4 pts) A block is pushed as shown. What is the magnitude of the friction force between the block and the floor?

\[ F_{max} = \mu_s N = 0.6 (60 \text{ N}) = 36 \text{ N} \]

10. (4pts) Dr. Arzad is pushing on a wall with a force of \((3\hat{i} + 4\hat{j})\) lb. What is the force (in notation) of the wall on her?

\[ F_w = -F_a = -(3\hat{i} + 4\hat{j}) \text{ lb} \]

11. (4pts) What is the drag force on an 8" diameter, 10 lb bowling ball falling downward toward the earth when it has reached its terminal velocity of 218 ft/s?

Values to use if you need them, are \( \rho = 0.02571 \text{ slug/ft}^3 \) and \( C_d = 0.47 \).

\[ D-W = 0 \quad D = 10 \text{ lb} \]

12. (4 pts) A 12 ft diameter merry-go-round spins at constant speed of 6 rpm. What is its angular speed in rad/sec?

\[ \omega = \frac{6 \text{ rev/min} \cdot \frac{2\pi \text{ rad}}{1 \text{ rev}}}{60 \text{ sec}} = 0.628 \text{ rad/sec} \]

13. (4pts) A small train (1 engine and 10 car cars) is accelerating at 0.6 ft/s² on level ground with a tractive force of 100 kip. How does the coupling force (C) between the engine and first coal car compare to the tractive force (T)?

A. C < T  
B. C = T  
C. C > T