1. A ball is thrown straight up. The ball is released 1.5 m above the ground with an initial speed of 22 m/s. What is the maximum height (above the ground) that the ball raises and how long is the ball in the air?

2. The planet Venus is $6.71 \times 10^7$ miles from the sun and takes 224 days to complete one revolution around the sun. What is the centripetal acceleration, in m/s/s, of Venus? There are 1609 m in 1 mile.

3. A stunt driver starts from rest 30 m from the edge of a 20 m high cliff. The acceleration of the car can be describe by $a = \sqrt{r}$. How far from the cliff's edge does the car land?

4. A racecar finishes the race and begins to decelerate. The equation (magnitude) for this deceleration is given by $a(t) = 5t^2$. If the racecar takes 3.5 s and 250 m to come to a stop, what was the speed of the racecar as it passed the finish line?

5. A firefighter 50.0 m from a burning building directs a stream of water from a fire hose at an angle of 35° above the horizontal. If the speed of the exiting stream of water is 45 m/s and 1 m above the ground, at what height will the water strike the building?

6. A baseball is tied to a string and twirled in a circle as shown in the diagram. If the speed of the ball is 5 m/s and the acceleration vector is 9 m/s/s, 55° from the velocity vector, what is the radius of the circle and at what rate is the ball changing its speed?

![Diagram of a baseball in a circular motion with acceleration vector and radius labeled.]
7. A skier leaves the ramp of a ski jump with a velocity of 12 m/s, 25° above the horizontal as shown. The slope is inclined a 40°. Find the distance down the slope where the sky jumper lands.

8. A basketball is shot from 2m above the floor. The basketball hoop is 5m away and 3.05m above the floor. If the basketball is shot at a 50° angle, at what speed should the basketball be shot in order to make it in the hoop?

9. A small package starts from rest on top of an icy (frictionless) roof. If the roof is 5m long and the building is 3m tall, how far from the base of the building does the package land?
Physics 121 Practice Problems (Exam 1)

1. \( h = \frac{V_y^2 - V_{y_i}^2}{2g} \)
\( V_y = V_{y_i} + 2a(t - t_0) \)
\( h = 26.2 \text{ m} \) (max height)
\( y = y_i + V_{y_i}t + \frac{1}{2}at^2 \)
\( 0 = 1.5 + (2.2)(t) + \frac{1}{2}(-9.8)(t)^2 \)
\( t = 4.56 \text{ s} \) (time in the air)

2. \( r = \left(6.7 \times 10^4 \text{ m/s} \right) \left(160 \text{ km} \right) = 1.09 \times 10^8 \text{ m} \)
\( t = \left(224 \text{ days} \right) \left(24 \times 3600 \text{ s} \right) = 1.935 \times 10^6 \text{ s} \)
\( V = \frac{\text{distance}}{\text{time}} = \frac{2 \pi c}{1.935 \times 10^6} = 3.507 \times 10^9 \text{ m/s} \)
\( A_c = \frac{V^2}{r} = \frac{(3.507 \times 10^9)^2}{1.09 \times 10^8} = 1.14 \times 10^2 \text{ m/s}^2 \)

3. \( v = \frac{\Delta x}{\Delta t} \)
\( V = \left(\frac{3}{2} \right) \left(6.16 + t \right) \)
\( 30 \text{ m} = \frac{4}{15} \left(6.16 + t \right) \)
\( t = 6.614 \text{ s} \)
\( V = \left(\frac{3}{2} \right) \left(6.16 + 6.614 \right) = 11.34 \text{ m/s} \)

3 cont. \( V = \frac{11.4 \text{ m/s} \cdot 2 \text{ m}}{60 \text{ m}} = 0.32 \text{ m/s} \)
\( x = 1.134 \text{ m} \left(2.020 \text{ s} \right) = 22.9 \text{ m} \)

4. \( \Delta v = \frac{\Delta x}{\Delta t} \)
\( V = \frac{3}{2} t^2 + V_i \)
\( O = \frac{5}{2} \left(3.8 \right)^2 + V_i \)
\( V = 7.5 \text{ m/s} \)

5. \( x = \text{motion} \)
\( 50 \text{ m} = 45\% \cos 35^\circ \cdot t \)
\( t = 1.36 \text{ s} \)
\( Y = V_i + V_{y_i}t + \frac{1}{2}at^2 \)
\( Y = 1 + 45\% \sin 35^\circ \cdot (1.36) + \frac{1}{2}(-9.8)(1.36)^2 \)
\( Y = 27.0 \text{ m} \)

6. \( A_c = \frac{V^2}{r} \)
\( A_c = 5.16 \text{ m/s} \)
\( \text{This is the rate the ball changes its speed} \)
\( A_c = 9.8 \text{ m/s} \)
\( \text{and} A_c = \frac{V^2}{r} \)
\( 7.37 \text{ m/s} = \left(\frac{5}{3} \text{ m/s} \right)^2 \)
\( r = 3.39 \text{ m} \)

7. \( y = 12\% \cos 25^\circ \cdot t \)
\( t = \left(9.195 \times 10^5 \text{ s} \right) \)
\( V = \frac{1}{2} \left(-1.85 \right) \cdot t \cdot 4 \left(4.25\sin 25^\circ \right) \)
\( y = -1.14\sin \theta \cdot x^2 + 0.4663 \cdot x \)

8. \( x = v \cdot t \)
\( 6 \text{ m} = \cos 50^\circ \cdot t \)
\( O = -4.13 \times 10^3 \cdot x^2 + 0.4663 \cdot x \)
\( x = \frac{1.305}{4.13 \times 10^3} = 3.12 \text{ m} \)
\( y = -\tan 40^\circ \cdot x \)
\( y = -40^\circ \cdot \left(3.12 \text{ m} \right) = 26.25 \text{ m} \)
\( \theta = 40^\circ \cdot \left(3.12 \text{ m} \right) = 26.25 \text{ m} \)

9. \( x = \text{motion} \)
\( 50 \text{ m} = 45\% \cos 35^\circ \cdot t \)
\( t = 1.36 \text{ s} \)
\( v = 7.68 \text{ m/s} \)
\( \text{This is the velocity the package leaves the roof} \)

Note: the acceleration down the roof is the component of g down the roof.

Projectile Motion:
\( V_x = 2 \text{ m/s} \)
\( V_y = 2 \text{ m/s} \)
\( V = 7.68 \text{ m/s} \)
\( \text{The time the projectile is in the} \)
\( 4.9t^2 + 4.622t - 3 = 0 \)
\( \text{Equation:} \)
\( t = 0.452 \pm \left(4.622^2 - 4 \cdot (4.9) \cdot 3 \right)^{1/2} \)
\( x = 7.68 \cdot 0.452 = 3.45 \text{ s} \)
\( Y = 0.4420 \cdot (0.35) = 2.71 \text{ m} \)
1. Mark, running at constant speed of 5m/s, runs past Jim who is at rest on a motorcycle. After waiting 3s, Jim starts to accelerate at 1.5 m/s² to catch Mark. How much time does it take for Jim to catch and get in front of Mark by 15m?

**Hint:**
1. \( t + t - 3 \) will be useful
2. \( x_{\text{Mark}} + 15 \) and \( x_{\text{Jim}} \) will be useful

2. The speed of a bullet as it travels down the barrel of a rifle toward the opening is given by \( v = -5\times10^7 t^2 + 3\times10^5 t \), where \( v \) is in meters per second and \( t \) is in seconds. The acceleration of the bullet just as it leaves the barrel is zero. What is the length of the barrel?

**Hint:** You will need to find \( a(t) \) and \( x(t) \)

3. A rock is spinning in a circle with a radius of 1.2m. When the radius makes a 45° angle with the vertical and the rock is on its way up, the acceleration vector is \(-25\hat{e} + 20\hat{\jmath}\).

a. What is the speed of the rock?
b. At what rate is the rock slowing down?

**Hint:** find \( a_r \) and \( a_t \)

4. Two balls are fired on a level field. Both have a speed of 45m/s. One ball is fired straight up and the other ball is fired at 50° from the horizontal. If the two balls are fired 50m apart, explain how to fire the two balls so they hit in the air? Hint: there are two answers.

5. A cannon ball is fired with a speed of 20m/s at an angle of 22° above the horizontal. The cannon ball begins level with the top of a mountain and 65m to the left. The mountain has the shape of an upside down parabola given by the equation \( y = -x^2 \). Where does the cannon ball hit the mountain?

**Hint:** Where are you going to put your origin?
1. Mark

\[ x_2 = \frac{1}{2} (1.5 \ m/s^2) t - 3^2 \]

\[ x_2 = x_i + 15 \]

\[ \frac{1}{2} (1.5)(t - 3)^2 = 5t + 15 \]

\[ 0.75t^2 - 6t + 9 = 5t + 15 \]

\[ 0 = -0.75t^2 + (5 + 6t) + 15 + 0.75 \]

\[ 0 = -0.75t^2 + 11.5t + 18.25 \]

\[ t = \frac{-11.5 \pm \sqrt{(11.5)^2 - 4(-0.75)(18.25)}}{2(-0.75)} \]

\[ t = \frac{-11.5 \pm \sqrt{134.8}}{-1.5} \]

\[ t = -0.81 \approx 13.48 \text{ s} \]

Jim is ahead of mark by 15 m after mark first passed him.

2. 

\[ v = (6 \times 10^2)t^2 + (3 \times 10^3)t \]

\[ a = \frac{dv}{dt} = -10 \times 10^3 t + 3 \times 10^3 = 0 \]

\[ 3 \times 10^3 - 1 \times 10^3 \]

\[ t = 3 \times 10^3 \text{ s} \]

the time the bullet leaves the barrel.

\[ x = -\frac{(6 \times 10^2)t^2}{3} + \frac{3 \times 10^3 t}{2} + 0 = 0 \text{ m at } t = 0 \]

\[ x = -\frac{5 \times 10^2 (3 \times 10^3)}{3} + \frac{3 \times 10^3 (3 \times 10^3)}{2} = 9.90 \text{ m} \]

the length of the barrel is 9.0 cm

3. 

\[ \alpha = \tan \theta = \frac{20}{28} = 0.714 \]

\[ \theta = 38.66^\circ \]

\[ \alpha = \theta = 141.3^\circ \]

\[ \alpha = 6.34^\circ \]

\[ \alpha = 6.34^\circ \]

\[ a_x = \sqrt{280^2 \cos (6.34^\circ)} = \frac{V^2}{1.2m} \]

\[ V = 6.179 \text{ m/s} \]

\[ a_y = \sqrt{280^2 \sin (6.34^\circ)} = -3.535 \text{ m/s}^2 \]

\[ v = \frac{20}{1.2} \]

\[ \theta = \tan^{-1} \left( \frac{20}{28} \right) = 38.66^\circ \]

\[ \theta = -38.66 + 180^\circ \]

\[ \theta = 141.3^\circ \]

\[ \alpha = 6.34^\circ \]

\[ a_x = \sqrt{280^2 \cos (6.34^\circ)} = \frac{V^2}{1.2m} \]

\[ V = 6.179 \text{ m/s} \]

b) \[ a_y = \sqrt{280^2 \sin (6.34^\circ)} = -3.535 \text{ m/s}^2 \]

slowly down

4. 

\[ x_1 = 5D_m = (4.5) \times 10^3 \times 10^3 = 44.92 = 45 \times t_2 - 9.3 \times t_2 \]

\[ t_1 = 1.729 \text{ s} \]

\[ t_2 = 44.92 = 45 \times t_2 - 9.3 \times t_2 \]

\[ t_2 = 45 \pm 33.83 \]

\[ 9.8 \text{ s} \]

\[ t_2 = 8.044 \text{ s on 1,140} \]

If projectile #1 is fired first - then projectile #2

is fired second - the projectile #2

must be fired (1.729 - 1.140) = 0.589 s later.

If projectile #2 is fired first - then projectile #2

must be fired (8.044 - 1.140) = 6.904 s later.

Note projectile will be coming down when struck.

5. 

\[ x = \frac{1}{2} a t^2 + (20 \times 0.5\times 22^\circ)(x-65) \]

\[ (x+65) = 18.54 \text{ t} \]

or \[ t = \frac{x+65}{18.54} \]

\[ y = -0.20(t^2) + 60 \times 22^\circ \sin (22^\circ) \]

\[ y = -0.20 \times 10^2 + 7.49 \times \frac{x+65}{18.54} \]

\[ y = -3.125 \times 10^2 \times x^2 + 130x + 4225 \]

\[ y = -3.125 \times 10^2 \times x^2 - 1449x - 33.95 \]

This is the equation of the projectile path.

It intersects with \[ y = -x^2 \] when

\[ x = -1.149 \text{ s} \]

or \[ x = -0.985 \text{ s} \]

or \[ x = -0.14 \text{ s} \]

\[ y = -x^2 \]

\[ x = -5.179 \text{ and } x = 6.649 \]

\[ y = -x^2 \]

projectile hits at \[ (-5.179, -26.82) \]

Note that the solution \[ (6.649, -44.21) \] is where

the projectile exits the mountain.