A particle is located by the vector \( \mathbf{r}(t) \) as measured from a given origin, where \( \mathbf{r}(t) = (2 - t) \mathbf{i} + (t^2/2) \mathbf{j} \).

\( \mathbf{r}(t) \) is measured in meters and \( t \) in seconds.

a. What is the vector displacement, \( \Delta \mathbf{r} \), of the particle between \( t = 0 \) s and \( t = 2 \) s?

\[
\Delta \mathbf{r} = \mathbf{r}(2) - \mathbf{r}(0) = 2\mathbf{j} - 2\mathbf{i} = -2\mathbf{i} + 2\mathbf{j} \text{ m}
\]

b. What is the average velocity during those 2 seconds?

\[
\mathbf{v} = \frac{\Delta \mathbf{r}}{2 \text{ s}} = -\mathbf{i} + \mathbf{j} \text{ m/s}
\]

c. What is the average speed during those 2 seconds?

\[
|\Delta \mathbf{r}| = |\mathbf{v}| = \sqrt{1^2 + 1^2} = \sqrt{2} \text{ m/s}
\]

d. What is the instantaneous velocity at \( t = 2 \) s?

\[
\mathbf{v} = \frac{\Delta \mathbf{r}}{\Delta t} = -\mathbf{i} + \mathbf{j} \text{ m/s}
\]

e. What is the instantaneous acceleration at \( t = 2 \) s?

\[
|\Delta \mathbf{v}| = \sqrt{1^2 + 2^2} = \sqrt{5} \text{ m/s}
\]

f. When, if ever, is the particle at the origin?

\[
\begin{align*}
x \text{ is 0 when } 2 - t &= 0 \rightarrow t = 2 \\
y \text{ is 0 when } \frac{t^2}{2} &= 0 \quad t = 0
\end{align*}
\]
A car starts from rest around a curve with a radius of 100 m. The car's motion is clockwise as shown below. The tangential acceleration of the car is a constant 2 m/s².

a. How long does it take for the centripetal acceleration of the car to equal 4 m/s²?

\[ a_c = \frac{v^2}{r} = 4 = \frac{2^2}{100} \rightarrow t = 10 \text{ sec} \]

b. At that time, how far has the car traveled around the curve?

\[ s = \frac{1}{2}at^2 = 100 \text{ m} \]

c. What angle, in radians, has the car traveled around the curve?

\[ \theta_1 = \frac{s}{r} = 1 \text{ rad} \]

d. Locate the approximate position of the car at this time and include vectors showing the tangential and radial acceleration.

e. What angle does the total acceleration make with respect to the radial direction?

\[ \theta_2 = \tan^{-1} \frac{1}{2} \]
A 2 kg object moves along the x axis under the influence of the force shown above. At time \( t = 0 \), the velocity of the object is \( v_x(0) = 2.0 \text{ m/s} \) and it is located at \( x(0) = 1.0 \text{ m} \).

a. What is \( a_x \) when \( t = 3 \text{ s} \)?

\[
\alpha_x = 3 \text{ m/s}^2
\]

b. What is \( v_x \) at \( t = 3 \text{ s} \)?

\[
v_x = 2.0 + \int_0^3 a_x \, dt = 2.0 + 4.5 = 6.5 \text{ m/s}
\]

c. \( v_x \) at \( t = 3 \text{ s} \) is \underline{larger} than \( v_x \) at \( t = 2 \text{ s} \)? (The choices are larger, the same as, or smaller.)

\[
\text{for times}
\]

d. At what time during the first 5 seconds of motion is \( v_x \) the largest?

\[
v_x \text{ is largest at } t \text{ between 4 and 5s}
\]
a. Describe a real object that could have the free-body diagram shown above. (Include in your description the directions of the net velocity and acceleration vectors.)

A book given an initial push up an incline that is still going up but slowing down.

b. On the above diagram, carefully sketch in the net force acting on the object.

c. If the magnitudes of the kinetic friction and gravitational forces are 4 and 10 Newtons respectively, what is the magnitude of the normal force?

8N

d. For the magnitudes given in part c), what is the magnitude of the net force acting on the object.

10N
A projectile is launched at an angle of 35° above the horizontal with an initial velocity of \( v_0 \). It reaches its highest point 4 seconds after being launched. Use \( g = -10 \text{ m/s}^2 \).

a. What are the equations for \( v_x(t) \), and \( v_y(t) \)? (Your answers should be in terms of numerical values and \( t \) and \( v_0 \).)

\[
\begin{align*}
v_x &= v_0 \cos 35° = v_0 \cdot \frac{3}{5} \\
v_y &= v_0 \sin 35° - gt = v_0 \frac{4}{5} - 10t
\end{align*}
\]

b. What are the equations for \( x(t) \) and \( y(t) \)? (Your answers should be in terms of numerical values and \( t \) and \( v_0 \).)

\[
\begin{align*}
x(t) &= \frac{3}{5} v_0 t \\
y(t) &= \frac{4}{5} v_0 t - 5t^2
\end{align*}
\]

c. What is the numerical value of \( v_0 \)?

At \( t = 4 \), \( v_y = 0 \)

\[
0 = v_0 \frac{4}{5} - 40 \rightarrow v_0 = 50 \text{ m/s}
\]

d. What is the maximum height reached by the projectile?

\[
y(t) = 50 \cdot \frac{4}{5} - 5 \cdot 4^2 = 160 - 80 = 80 \text{ m}
\]

e. At the instant that the projectile is at its maximum height, what are its vector velocity and acceleration?

\[
\begin{align*}
\vec{v} &= 30 \hat{i} \\
\vec{a} &= -10 \hat{j}
\end{align*}
\]

f. When the projectile hits the ground, what are its vector velocity and acceleration?

\[
\begin{align*}
y(t) &= 0 = 40t - 5t^2 = t(40-5t) \quad t=8 \\
v_y(8) &= 40 - 80 = -40 \\
\vec{v} &= 30 \hat{i} - 40 \hat{j} \text{ m/s}, \quad \vec{a} = -10 \frac{\text{m}}{\text{s}^2}
\end{align*}
\]