Name________________________________

Oct. 6, 2009

Phys 2112, Fall 2009
Quiz #1

1. The kinetic energy of some protons inside the nucleus can be taken as $20\,\mathrm{MeV}$.
Based on this, do we need relativity describe the motion of protons inside the nucleus? (Use $m_{\mathrm{p}} = 1.67 \times 10^{-27}\,\mathrm{kg}$.)

The kinetic energy is

$$20\,\mathrm{MeV}\left(\frac{1.602 \times 10^{-13}\,\mathrm{J}}{1\,\mathrm{MeV}}\right) = 3.2 \times 10^{-12}\,\mathrm{J}$$

Use $v^2 = \frac{2K}{m}$, then

$$v^2 = \frac{2K}{m} = \frac{2(3.2 \times 10^{-13}\,\mathrm{J})}{1.67 \times 10^{-27}\,\mathrm{kg}} = 3.8 \times 10^{15}\,\tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v = 6.2 \times 10^{7}\,\tfrac{\mathrm{m}}{\mathrm{s}}$$

which is about 20% of the speed of light, not "very small". If one wants better than approximate numbers, one should incorporate relativity.

2. Polar coordinates: If a, b and c are constants, what kind of geometric figure is

$$\rho = \frac{c}{a\cos\phi + b\sin\phi} \qquad ?$$

(Hint: It's a relatively simple answer.)

"Cross-multiplying" the given relation gives

$$\rho(a\sin\phi + b\cos\phi) = c \qquad \Longrightarrow \qquad a\rho\sin\phi + b\rho\cos\phi = c$$

Use the relations between (x, y) and (ρ, ϕ) to get

$$ax + by = c$$

which is a straight line.

3. Suppose for a particle moving in one dimension, the velocity is given by

$$v(t) \;=\; Ae^{-t/(2.0\,s)}$$

where A is some constant, and $v(0) = 3.0\,\frac{\mathrm{m}}{\mathrm{s}}$ and $x(0) = 4.0\,\mathrm{m}$.

Find A and then give expressions for $a(t)$, $v(t)$ and $x(t)$. Make rough sketches for these functions.

Since from the given form for $v(t)$,

$$v(0) = Ae^{-0} = A = 3.0\,\tfrac{\mathrm{m}}{\mathrm{s}}$$

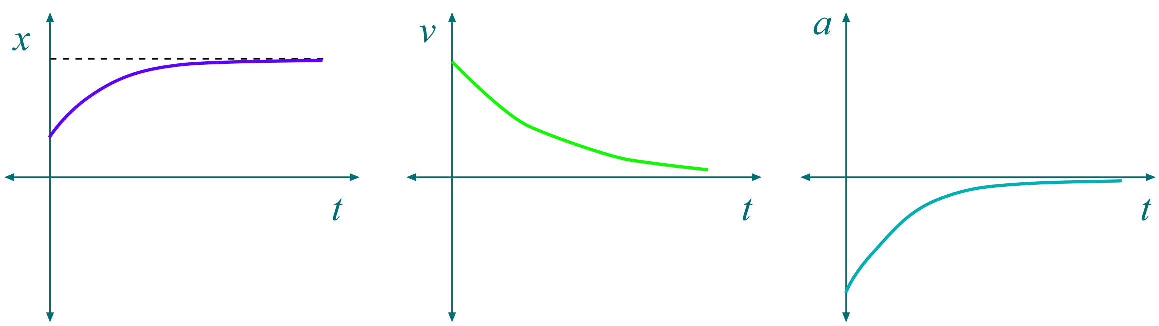
then $A = 3.0\,\frac{\mathrm{m}}{\mathrm{s}}$ and $v(t) = (3.0\,\frac{\mathrm{m}}{\mathrm{s}})e^{-t/2}$. Then the acceleration is

$$a(t) = \frac{dv}{dt} = (3.0\,\tfrac{\mathrm{m}}{\mathrm{s}})\left(-\frac{1}{2.0\,\mathrm{s}}\right)e^{-t/(2.0\,s)} = -1.5\,\tfrac{\mathrm{m}}{\mathrm{s}^2}e^{-t/(2.0\,s)}$$

and x is found from integrating v,

$$\begin{aligned} x &= x_0 + \int_0^t v(t')\,dt' = (4.0\,\mathrm{m}) + (3.0\,\tfrac{\mathrm{m}}{\mathrm{s}})(-2.0\,\mathrm{s})e^{-t/(2.0\,s)}\Big|_0^t \\ &= (4.0\,\mathrm{m} + 6.0\,\mathrm{m}) - (6.0\,\tfrac{\mathrm{m}}{\mathrm{s}})e^{-t/(2.0\,s)} \;=\; 10\,\mathrm{m} - (6.0\,\tfrac{\mathrm{m}}{\mathrm{s}})e^{-t/(2.0\,s)} \end{aligned}$$

These functions have the appearance shown here:



Show work for all problems and include the right units!

$c = 2.998\times10^{8}\,\frac{\mathrm{m}}{\mathrm{s}}$ $\quad h = 6.626\times10^{-34}\ \mathrm{J\cdot s}$ $\quad 1\,\mathrm{eV} = 1.602\times10^{-19}\ \mathrm{J}$ $\quad m_{\mathrm{p}} = 1.67\times10^{-27}\,\mathrm{kg}$

$\mathrm{M} \equiv 10^6$ $\quad \mathrm{k} \equiv 10^3$ $\quad K = \frac{1}{2}mv^2$ $\quad p = mv$ $\quad \lambda = \frac{h}{p}$

$x = \rho\cos\phi$ $\quad y = \rho\sin\phi$ $\quad \rho = \sqrt{x^2+y^2}$ $\quad \tan\phi = \frac{y}{x}$ $\quad \frac{d}{dx}(e^{ax}) = ae^{ax}$