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Phys 2112, Spring 2010
Quiz #1

1. For electrons at the center of the sun, the kinetic energy is roughly 3×10^{-16} J. Do we need relativity to describe the motions of these electrons?

Find the speed of the electrons:

$$\tfrac{1}{2}mv^2 = 3 \times 10^{-16}\ \text{J} \qquad \Longrightarrow \qquad v^2 = \frac{2(3 \times 10^{-16}\ \text{J})}{m} = \frac{2(3 \times 10^{-16}\ \text{J})}{(9.11 \times 10^{-31}\ \text{kg})} = 6.6 \times 10^{14}\ \tfrac{\text{m}^2}{\text{s}^2}$$

This gives

$$v = 2.6 \times 10^{7}\ \tfrac{\text{m}}{\text{s}}$$

which is roughly a tenth of the speed of light; we *would* probably insist on using relativity if we want better than rough answers!

2. Polar coordinates: Express the line

$$Ax + By = C$$

as an equation in *polar* coordinates of the form $r = f(\phi)$. (That is, find $f(\phi)$.)

Substitute for x and y:

$$Ar\cos\phi + Br\sin\phi = C \qquad \Longrightarrow \qquad r(A\cos\phi + B\sin\phi) = C$$

This gives

$$r = \frac{C}{(A\cos\phi + B\sin\phi)} \equiv f(\phi)$$

3. A particle moves in a circle of radius 5.0 cm centered at the origin, with constant speed $0.800\,\frac{\text{m}}{\text{s}}$.

Write down the equations of motion. (That is, $x(t)$ and $y(t)$.)

Here the period is given by

$$T = \frac{2\pi R}{v} = \frac{2\pi(0.050\ \text{m})}{0.800\,\frac{\text{m}}{\text{s}}} = 0.393\ \text{s}$$

so that the angular frequency is

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{(0.393\ \text{s})} = 16\ \text{s}^{-1}$$

and the (suitable) equations of motions are

$$x = (5.0\ \text{cm})\cos(16\ \text{s}^{-1}t) \qquad y = (5.0\ \text{cm})\sin(16\ \text{s}^{-1}t)$$

4. A particle moves in one dimension with an acceleration given by

$$a_x = (6.0\,\tfrac{\text{m}}{\text{s}^3})t$$

If the particle starts from rest at the origin, find $v(t)$ and $x(t)$.

For the velocity we get

$$v(t) = \int a(t')\,dt' = (3.0\,\tfrac{\text{m}}{\text{s}^3})t^2$$

for which we used the fact $v(0) = 0$, and the location is

$$x(t) = \int v(t')\,dt = (1.0\,\tfrac{\text{m}}{\text{s}^3})t^3$$

for which we used the fact $x(0) = 0$.

Show work for all problems and include the right units!

$c = 2.998{\times}10^8\,\frac{\text{m}}{\text{s}}$ $\quad h = 6.626{\times}10^{-34}$ J·s $\quad 1$ eV $= 1.602{\times}10^{-19}$ J $\quad \text{M} \equiv 10^6$ $\quad \text{k} \equiv 10^3$

$m_\text{p} = 1.67 \times 10^{-27}$ kg $\quad m_\text{e} = 9.11 \times 10^{-31}$ kg $\quad K = \frac{1}{2}mv^2$ $\quad p = mv$ $\quad \lambda = \dfrac{h}{p}$

$x = r\cos\phi$ $\quad y = r\sin\phi$ $\quad r = \sqrt{x^2 + y^2}$ $\quad \tan\phi = \dfrac{y}{x}$ $\quad v = \dfrac{2\pi R}{T}$ $\quad \omega = \dfrac{2\pi}{T}$