Name________________________________

Physics 120 Quiz #1, January 13, 2012

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. A car is being driven down a long straight road at a constant velocity. The driver decides to remove their foot from the accelerator pedal and the car subsequently begins to slow down but continues moving in its original direction.
   a. The car is experiencing an interaction because the speed is changing.
   b. The car is experiencing an interaction because its direction is changing.
   c. The car is experiencing an interaction because its speed and its direction are changing.
   d. The car is experiencing no interactions because its speed is constant.
   e. The car is experiencing no interactions because its speed is constant and its direction is not changing.

2. An electron ($m_e = 9.11x10^{-31}$ *kg*) is traveling with a speed of *0.172c*, where $c = 3x10^8$ *m/s* in a direction of $\hat{v} = \langle 0.524, -0.621, 0.583 \rangle$.

   a. What is the momentum of the electron?

$$\vec{p} = \gamma m \vec{v} = \gamma m |\vec{v}| \hat{v}$$

$$\vec{p} = \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \right) m |\vec{v}| \hat{v} = \left(\frac{1}{\sqrt{1 - (0.172)^2}} \right) \times 9.11 \times 10^{-31} kg \times 0.172 \times 3 \times 10^8 \tfrac{m}{s} \times \langle 0.524, -0.621, 0.583 \rangle$$

$$\vec{p} = \langle 2.5, -2.96, 2.78 \rangle \times 10^{-23} \tfrac{kgm}{s}$$

   b. An electron detector is turned on at a location $\vec{r}_i = \langle 1,0,0 \rangle m$ and when the electron passes by the detector. If a second detector is located at a spot $\vec{r}_f = \langle 111.7, -131.2, 123.0 \rangle m$, how long did it take to reach the second detector if it's velocity is assumed constant through this region?

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg} \Delta t$$

$$\langle 111.7, -131.2, 123.0 \rangle m = \langle 1,0,0 \rangle m + \left(0.172 \times 3 \times 10^8 \tfrac{m}{s}\right) \langle 0.524, -.621, 0.583 \rangle \Delta t$$

$$\begin{cases} 111.7m = 1m + 2.7 \times 10^7 \tfrac{m}{s} \Delta t \rightarrow \Delta t = 4.1 \times 10^{-6} s \\ -131.2m = 0m - 3.2 \times 10^7 \tfrac{m}{s} \Delta t \rightarrow \Delta t = 4.1 \times 10^{-6} s \\ 123.0m = 0m + 3.0 \times 10^7 \tfrac{m}{s} \Delta t \rightarrow \Delta t = 4.1 \times 10^{-6} s \end{cases}$$

$$\therefore \Delta t = 4.1 \times 10^{-6} s = 4.1 \mu s$$

Useful formulas:

$\vec{p} = \gamma m\vec{v}$

$\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}$

$\vec{v}_{avg} = \dfrac{\vec{v}_i + \vec{v}_f}{2}$

$\vec{F}_g = m\vec{g}$

$\vec{F}_{gravity} = \dfrac{GM_1M_2}{r_{12}^2}\hat{r}_{12}$

$\vec{F}_{spring} = -k\vec{s}; \quad \vec{s} = (L - L_o)\hat{s}$

$W = \int \vec{F}\cdot d\vec{r} = \Delta KE = -\Delta U$

$U_g = -\dfrac{GM_1M_2}{r}$

$U_g = mgy$

$U_s = \dfrac{1}{2}ks^2$

$KE = \dfrac{1}{2}mv^2$

$KE = (\gamma - 1)mc^2$

$k_{eff,parallel} = n_{parallel}k_{individual}$

$k_{eff,series} = \dfrac{k_{individual}}{n_{series}}$

$stress = Ystrain \rightarrow \dfrac{F}{A} = Y\dfrac{\Delta L}{L}$

Momentum Principle:

$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t; \quad \Delta t = \text{large}$

$\vec{p}_f = \vec{p}_i + \vec{F}_{net}dt; \quad dt = \dfrac{\Delta t}{n} = \text{small}$

Position-update:

$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \vec{r}_i + \dfrac{\vec{p}}{m\sqrt{1+\dfrac{p^2}{m^2c^2}}}\Delta t; \quad \Delta t = \text{large}$

$\vec{r}_f = \vec{r}_i + \vec{v}_f dt; \quad dt = \dfrac{\Delta t}{n} = \text{small}$

Energy principle:

Geometry /Algebra

Circles	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

Quadratic equation: $ax^2 + bx + c = 0$,

whose solutions are given by: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

magnitude of a vector: $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$

writing a vector: $\vec{a} = \langle a_x, a_y, a_z \rangle = |\vec{a}|\hat{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

Useful Constants

$g = 9.8\,\frac{m}{s^2}$

$G = 6.67\times10^{-11}\,\frac{Nm^2}{kg^2}$

$1e = 1.6\times10^{-19}C$

$k = \dfrac{1}{4\pi\varepsilon_o} = 9\times10^{9}\,\frac{C^2}{Nm^2}$

$\varepsilon_o = 8.85\times10^{-12}\,\frac{Nm^2}{C^2}$

$1eV = 1.6\times10^{-19}J$

$\mu_o = 4\pi\times10^{-7}\,\frac{Tm}{A}$

$c = 3\times10^{8}\,\frac{m}{s}$

$h = 6.63\times10^{-34}Js$

$m_e = 9.11\times10^{-31}kg = \dfrac{0.511MeV}{c^2}$

$m_p = 1.67\times10^{-27}kg = \dfrac{937.1MeV}{c^2}$

$m_n = 1.69\times10^{-27}kg = \dfrac{948.3MeV}{c^2}$

$1amu = 1.66\times10^{-27}kg = \dfrac{931.5MeV}{c^2}$

$N_A = 6.02\times10^{23}$

$Ax^2 + Bx + C = 0 \rightarrow x = \dfrac{-B \pm \sqrt{B^2 - 4AC}}{2A}$