Physics 205 Test 1

I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Name ______________________ Signature ______________________

Questions (5 for 8 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. Imagine you are watching a transmission from someone on Mars which at the time is 1.5 light-hours from Earth. The clock on the wall behind the Martian in the video reads 7:30 am. Your watch reads the same time. Is the Martian clock synchronized with yours?

   (a) No. (b) Yes. (c) Not enough information. Explain your answer.

2. An inertial clock present at two events always measures a *shorter* time than a pair of synchronized clocks in *any* inertial reference frame would register between the same two events (as long as the events don't occur at the same place in that frame).

   T or F? Explain.

3. What was wrong with Galileo? Or at least his electromagnetic field transformations?

DO NOT WRITE BELOW THIS LINE.

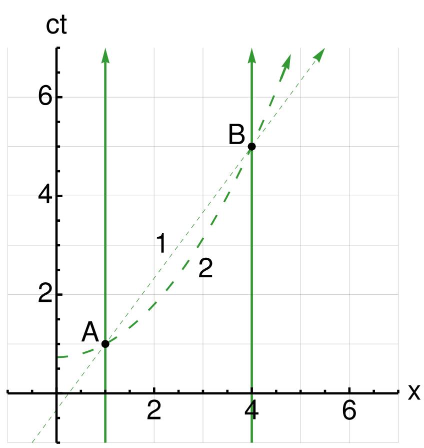
4. Firecracker A is 300 m from you. Firecracker B is 600 m from you in the same direction. You see both explode at the same time. Let Event 1 be firecracker A explodes and let Event 2 be firecracker B explodes. Does Event 1 occur before, after, or at the same time as Event 2? Explain.

5. Consider the spacetime diagrams below showing two events A and B and the worldlines of two clocks 1 (short-dashed) and 2 (long-dashed) that are used to measure the time between events.

   (a) Which clocks measure the spacetime interval between events A and B? Explain.

   (b) Which clocks measure a proper time between A and B? Explain.

   (c) Which clocks measure a coordinate time between A and B? Explain.



Problems (3). Clearly show all reasoning for full credit. Use a separate sheet to show your work.

1. 15 pts. A proton travels with a speed $v = 4.0 \times 10^6\ m/s$ at an angle $\theta = 25°$ to the direction of the magnetic field with $\vec{B} = 0.4\ T\hat{j}$. What is the magnitude of the magnetic force on the proton?

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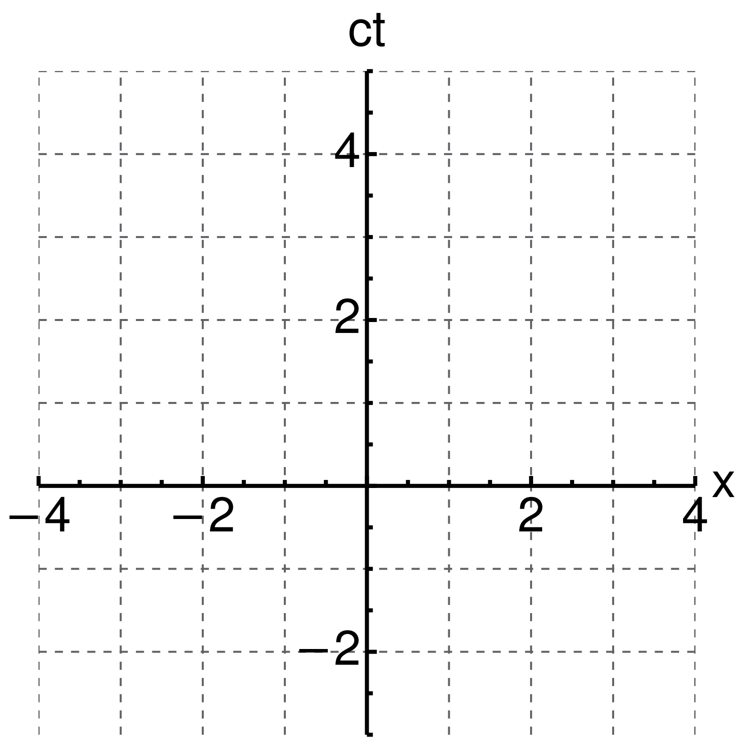
2. 20 pts. Draw a spacetime diagram that displays that displays worldlines for the following particles. Use the grid below and clearly mark each worldline with its particle label.

1. Particle A travels at a constant speed $|\vec{v}| = 3/5c$ in the $-x$ direction and passes the point $x = 0$ at time $t = -2\ s$.

2. Particle B is at rest at time $t = 0$ at position $x = 0$. It accelerates in the $+x$ direction asymptotically toward the speed of light as time passes.

3. A light flash C passes $x = 0$ at time $T = +3\ s$ as it travels in the in the $-x$ direction.



3. 25 pts. A muon is created by a the interaction of a cosmic-ray and an atom in the upper atmosphere at an altitude $y = 6 \times 10^4\ m$. After its creation the muon zooms downward at $v_m = 0.998c$ as measured by a stationary, ground-based observer. The muon decays into an electron and two neutrinos after $t_d = 1.5\ \mu s = 1.5 \times 10^{-6}\ s$ in it's frame.

1. If clocks on the ground were used to measure the same time interval t_d for the muon's lifetime, how far would the muon travel between it's creation and decay? Note: You are being asked to ignore special relativity and assume time is Newtonian.

2. If special relativity is true, then how far would the muon travel in the ground frame before it decays?

Physics 205 Equations

$$v = \frac{dx}{dt} \quad x = \frac{1}{2}at^2 + v_0 t + x_0 \quad v = at + v_0 \quad a_g = -g$$

$$\vec{F}_{net} = \sum \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \quad \vec{F}_{Earth} = -mg\hat{j} \quad a_c = \frac{v^2}{r}$$

$$KE = \frac{1}{2}mv^2 \quad KE_0 + PE_0 = KE_1 + PE_1 \quad PE_{Earth} = mgh \quad PE_V = qV$$

$$\vec{p}_i = \vec{p}_f \quad \vec{p} = m\vec{v}$$

$$\vec{F}_C = k_e \frac{q_1 q_2}{r^2}\hat{r} \quad \vec{E} \equiv \frac{\vec{F}}{q_0} \quad d\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{dq}{r^2}\hat{r}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{s} \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi}\frac{q d\vec{v} \times \hat{r}}{r^2} \qquad \vec{F}_B = q\vec{v} \times \vec{B} \qquad |\vec{F}_B| = |qvB\sin\theta|$$

$$\vec{E}_B = \vec{E}_A + \vec{v}_{BA} \times \vec{B}_A \quad \vec{B}_B = \vec{B}_A - \mu_0\epsilon_0\vec{v}_{BA} \times \vec{E}_A$$

Galilean Transformation
$x' = x - vt$
$y' = y$
$z' = z$
$t' = t$
$v'_x = v_x - v_O$
$v'_y = v_y$
$v'_z = v_z$

Coordinate Time	Spacetime Interval	Proper Time
Time between two events in an inertial frame measured with synchronized clocks	Time between two events measured by the same, inertial clock at both events.	Time between two events measured by the same clock at both events.
Δt	Δs	$\Delta\tau$
Frame dependent	Frame independent	Frame independent

$$\Delta s_{SR}^2 = \Delta t^2 - \Delta d^2 = \Delta s_{SR}'^2 \quad \text{or} \quad \Delta s_{SI}^2 = c^2\Delta t^2 - \Delta d^2 = \Delta s_{SI}'^2$$

$$\Delta\tau_{SR} = \int_{t_A}^{t_B} \sqrt{1 - v^2}dt \quad \text{or} \quad \Delta\tau_{SI} = \int_{t_A}^{t_B} \sqrt{1 - v^2/c^2}\, c\,dt$$

$$\Delta\tau_{SR} = \sqrt{1 - v^2}\Delta t \quad \text{or} \quad \Delta\tau_{SI} = \sqrt{1 - v^2/c^2}\, c\Delta t \qquad \text{fixed } v$$

$$\frac{d}{dx}(f(u)) = \frac{df}{du}\frac{du}{dx} \quad \int x^n dx = \frac{x^{n+1}}{n+1} \quad \int \frac{1}{x}dx = \ln x \quad \vec{A}\cdot\vec{B} = AB\cos\theta \quad |\vec{A}\times\vec{B}| = |AB\sin\theta|$$

$$\frac{d}{dx}(x^n) = nx^{n-1} \quad \frac{de^x}{dx} = e^x \quad \frac{d}{dx}(\ln x) = \frac{1}{x} \quad \frac{d}{dx}(\cos ax) = -a\sin ax \quad \frac{d}{dx}(\sin ax) = a\cos ax$$

$$\langle x\rangle = \frac{1}{N}\sum_i x_i \quad \sigma = \sqrt{\frac{\sum_i (x_i - \langle x\rangle)^2}{N-1}} \quad A = 4\pi r^2 \quad V = Ah \quad V = \frac{4}{3}\pi r^3$$

$$\frac{df(x)}{dx} = \lim_{\Delta x \to 0} \frac{f(x+\Delta x) - f(x)}{\Delta x} \qquad \int_a^b f(x)dx = \lim_{\Delta x \to 0} \sum_{n=1}^{N} f(x)\Delta x$$

$$\int \frac{1}{x}dx = \ln x \quad \int x^n dx = \frac{x^{n+1}}{n+1} \quad \int e^{ax}dx = \frac{e^{ax}}{a} \quad \int \frac{1}{\sqrt{x^2+a^2}}dx = \ln\left[x + \sqrt{x^2+a^2}\right]$$

$$\int \frac{x}{\sqrt{x^2+a^2}}dx = \sqrt{x^2+a^2} \quad \int \frac{x^2}{\sqrt{x^2+a^2}}dx = \frac{1}{2}x\sqrt{x^2+a^2} - \frac{1}{2}a^2 \ln\left[x + \sqrt{x^2+a^2}\right]$$

$$\int \sqrt{1-ax^2}dx = \frac{x}{2}\sqrt{1-ax^2} + \frac{\arcsin(\sqrt{a}x)}{2\sqrt{a}} \quad \int \frac{x^3}{\sqrt{x^2+a^2}}dx = \frac{1}{3}(-2a^2+x^2)\sqrt{x^2+a^2}$$

$$\int \frac{a}{(x^2+a^2)^{3/2}}dx = \frac{x}{a\sqrt{x^2+a^2}}$$

Physics 205 Constants and Conversions

Avogadro's number (N_A)	6.022×10^{23}	Speed of light (c)	$3 \times 10^8\ m/s$
k_B	$1.38 \times 10^{-23}\ J/K$	proton/neutron mass	$1.67 \times 10^{-27}\ kg$
$1\ u$	$1.67 \times 10^{-27}\ kg$	g	$9.8\ m/s^2$
Gravitation constant	$6.67 \times 10^{-11}\ N - m^2/kg^2$	Earth's radius	$6.37 \times 10^6\ m$
Coulomb constant (k_e)	$8.99 \times 10^9 \frac{N-m^2}{C^2}$	Electron mass	$9.11 \times 10^{-31}\ kg$
Elementary charge (e)	$1.60 \times 10^{-19}\ C$	Proton/Neutron mass	$1.67 \times 10^{-27}\ kg$
Permittivity constant (ϵ_0)	$8.85 \times 10^{-12} \frac{kg^2}{N-m^2}$	1.0 eV	$1.6 \times 10^{-19}\ J$
1 MeV	$10^6\ eV$	atomic mass unit (u)	$1.66 \times 10^{-27}\ kg$
Planck's constant (h)	$6.63 \times 10^{-34}\ Js$	Planck's constant (h)	$4.14 \times 10^{-15}\ eVs$
Permeability constant (μ_0)	$1.26 \times 10^{-6}\ Tm/A$	Rydberg constant (R_H)	$1.097 \times 10^7\ m^{-1}$
Becquerel (Bq)	$1\ decay/s$	Curie (Ci)	$3.7 \times 10^{10}\ Bq$