# Physics 205 Test 1

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

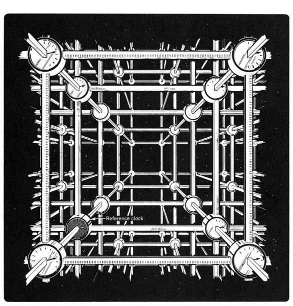
Name ______________________ Signature ______________________

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

1. Suppose you receive a message from a starbase that is 10 light-years from earth. The message is dated September 14, 2031. What year does your calendar indicate at the time of reception if your calendar and the station's calendar are correctly synchronized?
a. 2041 b. 2044 c. 2031 d. Other (specify). Explain your reasoning.

2. Since the laws of physics are (hopefully) the same in every inertial reference frame, there is no physically meaningful distinction between an inertial frame at rest and one moving at a constant velocity. True (T) or false (F). Explain your reasoning.

3. Consider the spacetime lattice shown in the figure. How do we measure the location of a spacetime event? How are the clocks at each lattice point related?



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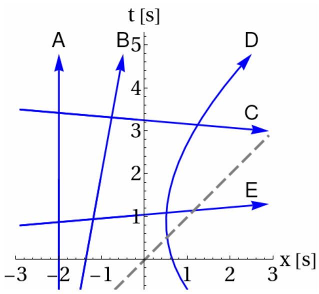
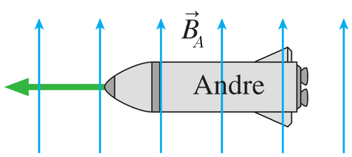
4. Consider the worldlines shown in the figure. Which worldline or worldlines cannot be correct? Explain why. The dashed, gray line represents the worldline of a light pulse from the origin.



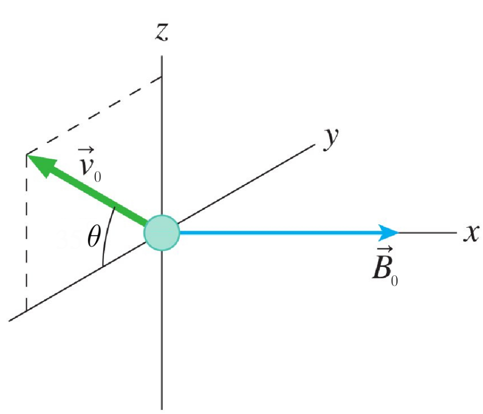

5. Andre is flying his spaceship to the left through the laboratory magnetic field. (a) Does Andre see a magnetic field? If so, in what direction does it point? (b) Does Andre see an electric field? If so, in what direction does it point?




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

1. 10 pts. A baseball pitcher can throw a ball with a speed of $v_p = 40\ m/s$. He is in the back of a pickup truck that is driving away from you. He throws the ball in your direction, and it floats toward you at a lazy $v_t = 10\ m/s$. What is the speed of the truck?

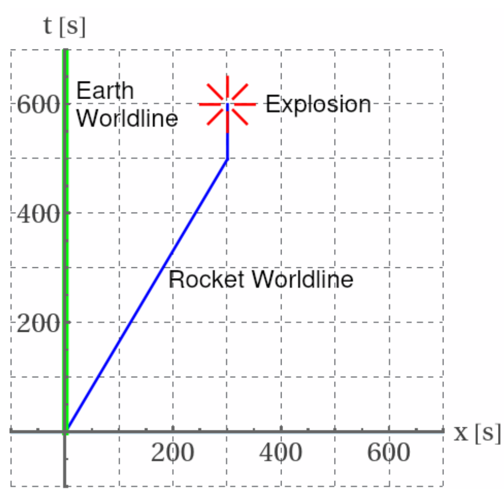
2. 15 pts. A particle of charge $q$ moves in the magnetic field $\vec{B} = B_0\,\hat{\imath}$ with a velocity $\vec{v}_0$ as shown in the figure that lies in the $y - z$ plane. The $y$ axis goes into the plane of the paper. What is the magnetic force $\vec{F}_B$ on the particle in terms of $q$, $v_0$, $B_0$, and $\theta$? Give your answer in component form ($i.e.$ $ijk$ notation).



3. 15 pts. Scientists in the laboratory create a uniform electric field $\vec{E} = E_0\,\hat{k}$ in a region of space where $\vec{B} = 0$. What are the fields in the reference frame of a rocket traveling in the positive $x$-direction at a velocity $\vec{v} = v_0\,\hat{\imath}$? Give your answer in component form (*i.e.* $ijk$ notation).

4. 20 pts. The spacetime diagram below shows the worldline of a rocket as it leaves the earth, travels for a while, comes to rest, and then explodes.

   1. The rocket leaves the Earth, stops in deep space, and explodes. What are the coordinates of each step?
   2. What is the rocket's constant speed relative to the Earth before it stops?
   3. A light signal from the Earth reaches the rocket just as it explodes. Where and when was this signal emitted?

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## Physics 205 Equations

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

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

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

$$\vec{p}_i = \vec{p}_f \quad \vec{p} = m\vec{v} \qquad v < c \text{ for material objects}$$

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

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

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

| 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 |
|---|---|
| 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. |
| $\Delta t$ | $\Delta s^2 = \Delta t^2 - \frac{\Delta d^2}{c^2}$ |
| Frame dependent | Frame independent |

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

$$\Delta t'_{SR} = \sqrt{1 - v^2}\Delta t_{SR} \quad \text{or} \quad \Delta t'_{SI} = \sqrt{1 - v^2/c^2}\; c\Delta t \qquad \text{fixed } v$$

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

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

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

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

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

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

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

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

## Physics 205 Constants and Conversions

| | | | |
|---|---|---|---|
| Avogadro's number ($N_A$) | $6.022 \times 10^{23}$ | Speed of light ($c$) | $3 \times 10^8\ m/s$ |
| Magnetic constant ($k_B$) | $1.38 \times 10^{-23}\ J/K$ | 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 ($\epsilon_0$) | $8.85 \times 10^{-12} \frac{kg^2}{N-m^2}$ | 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 ($\mu_0$) | $1.26 \times 10^{-6}\ Tm/A$ | Rydberg constant ($R_H$) | $1.097 \times 10^7\ m^{-1}$ |
| Becquerel ($Bq$) | $1\ decay/s$ | Curie ($Ci$) | $3.7 \times 10^{10}\ Bq$ |