

Physics 215 – Elementary Modern Physics
Equations for Test 1

The following equations you should memorize, and understand how to use them:

<u>4D distance</u> $s^2 = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2(\Delta t)^2 = -c^2\tau^2$	<u>Speed of Light</u> $c \approx 3.00 \times 10^8 \text{ m/s}$	<u>Energy</u> $E = \gamma mc^2$
<u>Length Contraction</u> $L = L_p / \gamma$	<u>Lorentz Factor</u> $\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$	<u>Momentum</u> $\vec{p} = \gamma m \vec{v}$
<u>Time Dilation</u> $\Delta t = \gamma \tau$	<u>Work</u> $\Delta E = W = \vec{F} \cdot \vec{d}$	<u>Force</u> $\vec{F} = \frac{d\vec{p}}{dt}$
	<u>Mass Formula</u> <u>Invariant Mass</u> $E^2 - (\vec{p}c)^2 = (mc^2)^2$ $E_{\text{tot}}^2 - (\vec{p}_{\text{tot}}c)^2 = (Mc^2)^2$	

The following equations you need not memorize, but you should know how to use them if given to you:

<u>Lorentz Boost</u> $x' = \gamma(x - vt)$ $t' = \gamma(t - vx/c^2)$ $y' = y$ $z' = z$	<u>Binomial Theorem</u> $(1 + \varepsilon)^n = 1 + n\varepsilon + \frac{1}{2}n(n-1)\varepsilon^2 + \dots$	<u>Velocity Formula</u> $\frac{\vec{u}}{c} = \frac{\vec{p}c}{E}$	<u>Lorentz Transform of velocity</u> $u'_x = \frac{u_x - v}{1 - vu_x/c^2}$ $u'_y = \frac{u_y}{\gamma(1 - vu_x/c^2)}$ $u'_z = \frac{u_z}{\gamma(1 - vu_x/c^2)}$
<u>Motion in a Magnetic Field</u> $p = qRB$	<u>Doppler Shift</u> $f = \frac{f_0}{\gamma(1 - v \cos \theta/c)}$	<u>Lorentz Transform of p and E</u> $p'_x = \gamma(p_x - vE/c^2)$ $E' = \gamma(E - vp_x)$ $p'_y = p_y,$ $p'_z = p_z$	
	<u>Electromagnetic Force</u> $\vec{F} = q\vec{E} + q\vec{u} \times \vec{B}$		

The following equations you should be able to derive from the equations above, with a bit of deduction:

<u>Potential and Kinetic Energy</u> $E_0 = mc^2$ $E_{\text{kin}} = (\gamma - 1)mc^2$	<u>Massless Particles</u> $E = \vec{p} c$ $ \vec{u} = c$	<u>Inverse Lorentz Boost</u> $x = \gamma(x' + vt')$ $t = \gamma(t' + vx'/c^2)$ $y = y'$ $z = z'$
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Layout of the exam: Below is an outline of the exam

This test consists of three parts. Please note that in parts II and III, you can skip one question of those offered.

Part I: Multiple Choice [20 points]

For each question, choose the best answer (2 points each)

[questions 1-10]

Part II: Short answer [20 points]

Choose **two** of the following three questions and give a short answer (1-3 sentences) (10 points each).

[questions 11-13]

Part III: Calculation: [60 points]

Choose **three** of the following four questions and perform the indicated calculations (20 points each)

[questions 14-17]