

Physics 215 – Elementary Modern Physics
Equations for Test 1

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

4D distance

$$s^2 = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2 (\Delta t)^2 = -c^2 \tau^2$$

Speed of Light

$$c \approx 3.00 \times 10^8 \text{ m/s}$$

Velocity Formula

$$\frac{\vec{u}}{c} = \frac{\vec{p}c}{E}$$

Length Contraction

$$L = L_p / \gamma$$

Lorentz Factor

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

Energy

$$E = \gamma mc^2$$

Momentum

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

Mass Formula
Invariant Mass

$$E^2 - (\vec{p}c)^2 = (mc^2)^2$$

$$E_{\text{tot}}^2 - (\vec{p}_{\text{tot}}c)^2 = (Mc^2)^2$$

Time Dilation

$$\Delta t = \gamma \tau$$

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

Lorentz Boost

$$x' = \gamma(x - vt)$$

$$t' = \gamma(t - vx/c^2)$$

$$y' = y$$

$$z' = z$$

Binomial Theorem

$$(1 + \varepsilon)^n = 1 + n\varepsilon + \frac{1}{2}n(n-1)\varepsilon^2 + \dots$$

Doppler Shift

$$f = \frac{f_0}{\gamma(1 - v \cos \theta/c)}$$

Lorentz Transform of p and E

$$p'_x = \gamma(p_x - vE/c^2)$$

$$E' = \gamma(E - vp_x)$$

$$p'_y = p_y,$$

$$p'_z = p_z$$

Lorentz Transform of velocity

$$u'_x = \frac{u_x - v}{1 - vu_x/c^2}$$

$$u'_y = \frac{u_y}{\gamma(1 - vu_x/c^2)}$$

$$u'_z = \frac{u_z}{\gamma(1 - vu_x/c^2)}$$

Motion in a Magnetic Field

$$p = qRB$$

Electromagnetic Force

$$\vec{F} = q\vec{E} + q\vec{u} \times \vec{B}$$

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

Potential and Kinetic Energy

$$E_0 = mc^2$$

$$E_{\text{kin}} = (\gamma - 1)mc^2$$

Massless Particles

$$E = |\vec{p}|c$$

$$|\vec{u}| = c$$

Inverse Lorentz Boost

$$x = \gamma(x' + vt')$$

$$t = \gamma(t' + vx'/c^2)$$

$$y = y'$$

$$z = z'$$

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]