Physics 241 Exam 1
Solutions & Mistakes

1. In the bunch reference frame:
   a) Length of bunch = (\gamma) (0, 25 cm) = (5.00 m)
   ⇒ (0) (0.25 cm) = \frac{5.00 m}{\gamma}
   ⇒ \gamma^2 = 2000 ⇒ \gamma \approx 45
   ⇒ \boxed{u = 0.99975c}

MISTAKES:
- BY FAR THE MOST COMMON MISTAKE WAS TO IGNORE (b) AND SAY \gamma = 2000. NO CREDIT.
- ARITHMETIC MISTAKE BUT CORRECT IDEA (-2) FOR EACH SUCH MISTAKE

1. (b) \( u \approx c \)

\( \frac{20 m}{u} = 3 \gamma_{LAB} \Rightarrow \gamma_{LAB} = 6.7 \times 10^{-8} s. \)
\( \gamma_{PROPER} = \frac{\gamma_{LAB}}{\gamma} = 4.9 \times 10^{-10} s. \)

MISTAKES:
- WHILE RECOGNIZING (\gamma_{LAB}) ≠ (\gamma_{PROPER})
  GET (\gamma_{PROPER}) WRONG -4
- DO NOT DISTINGUISH (\gamma_{LAB}) AND (\gamma_{PROPER})
  BUT GET (\gamma_{LAB}) CORRECT ⇒ 4 A+ S.
- NUMBER OF SIGNIFICANT FIGURES
  WRONG -4
\[ y = \frac{2.00 \text{ MeV}}{0.511 \text{ MeV}} = 3.91 = \frac{1}{\sqrt{1 - \frac{v_{1Z}}{c}^2}} \Rightarrow v_{1Z} = 0.967c \]

\[ \Rightarrow \frac{v_{1Z}}{c} = 0.76c \]

\[ \Rightarrow v_e = 1.54 \]

\[ \Rightarrow E_{\text{TOTAL}} = (\delta \epsilon_e)\langle 0.511 \text{ MeV} \rangle = 0.787 \text{ MeV} \]

\[ p = \frac{\delta \epsilon_{1Z}}{c} = \frac{0.598 \text{ MeV}}{c} = \left( \frac{1}{c} \right) \sqrt{(v_e^2 - 1)} (m_e c^2) \]

**MISTAKES:**

- IDEA CORRECT BUT WRONG \((v_1)\) - 4,
- REST OK
- \((v_{1Z})\) OK BUT SUBSEQUENT - 16,
- \((v_1)\) OK BUT NO \((\epsilon_e)\) OR \((p)\) - 10
3. a) 148 meV

\[ u = \frac{0.87c + 0.985c}{1 + \left(\frac{0.87c}{0.985c}\right)} = 0.999c \]

\[ \rho = \gamma m u = (21.9) \left(\frac{148 \text{ meV}}{c}\right) (0.999) \]

\[ = 3.23 \times 10^3 \text{ meV} \]

\[ \Rightarrow E_{\text{Total}} = \gamma (mc^2) = (21.9) (148 \text{ meV}) \]

\[ = 3.23 \times 10^3 \text{ meV} \]

- MISTAKES
  - Part (a) wrong, but (b) ok given (a) - part (a) - 0, part (b) full credit
  - Likewise for part (c).