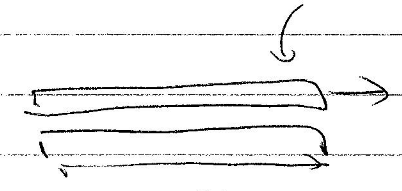
Marking Scheme P201 Midterm 2006

$L_0 = 15$ m



(10)

a) Lorentz contraction (1) $L = \frac{L_0}{\gamma}$ $\gamma = \frac{L_0}{L} = 1.5$

$\frac{v}{c} = \left(1 - \frac{1}{\gamma^2}\right)^{1/2}$

(2)
$\frac{v}{c} = 0.745$ $v = 2.24 \times 10^8$ m/s

b) $x' = \gamma(x - vt)$
$= \gamma x$ (1)
$= 15$ m

$t' = \gamma\left(t - \frac{vx}{c^2}\right)$ (2)

$t' = \frac{-(1.5)(0.745)(10)}{3 \times 10^8} = -37.3$ ns

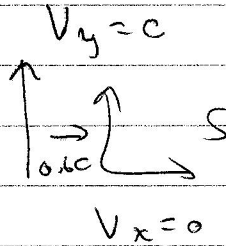
Yes it does since lightning is at 15 m and the car is at rest in frame S'. (1)

c) $\Delta t' = \frac{x'}{c} = 50$ ns (2)

so $t_3' = \Delta t' + t_2' = 50 \text{ ns} - 37.3 \text{ ns} = 12.8$ ns

Happens after the lightning strike. (1)

2.



Speed in S' is c (2)

$$V_x' = \frac{V_x - v}{1 - \frac{V_x v}{c^2}} = \frac{-0.6c}{1} = -0.6c$$ (1)

$$V_y' = \frac{V_y}{\gamma\left(1 - \frac{V_x v}{c^2}\right)} = \frac{c}{\gamma} = 0.8c$$ (1)

prefer this for

$$v' = \sqrt{v_x'^2 + v_y'^2} = \sqrt{0.6^2 + 0.8^2}\, c = c$$

3. $$(KE)_{max} = h\nu - \phi = \frac{hc}{\lambda} - \phi$$ (1.5)

Einstein's hypothesis for energy of photon (1.5)

$$eV = (KE_{max}) = \frac{1240 \text{ nm eV}}{405 \text{ nm}} - 0.9 \text{ eV}$$

$$eV = 2.16 \text{ eV}$$

$$V = 2.16 \text{ V}$$ (1.5)

no intensity dependence (1.5)

4 a) $$\vec{p} = \frac{m\vec{V}}{\sqrt{1-\frac{V^2}{c^2}}}$$

$$E = \frac{mc^2}{\sqrt{1-\frac{V^2}{c^2}}}$$ (1)

b) $$E = \frac{0.511}{\sqrt{1-(.95)^2}} = \frac{0.511}{0.312} = 1.64 \text{ MeV}$$ (.75)

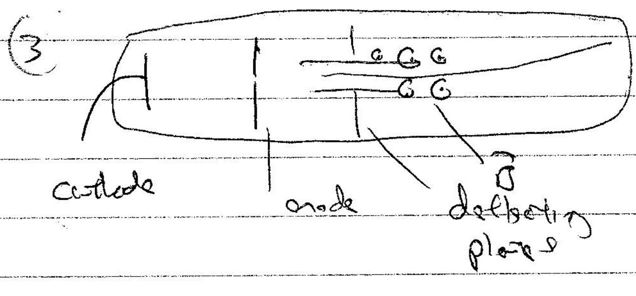
$$\vec{p}_x = \frac{(0.511)(0.95 \leftarrow V_x)}{(0.312)} = (1.64)(0.95) = 1.56 \ \frac{\text{MeV}}{c}$$ (.75)

$$p_y = 0 \quad (V_y = 0)$$
$$p_z = 0 \quad (V_z = 0)$$
(0.5)

c) $$E^2 - p^2c^2 = (1.64)^2 - (1.56)^2 = 0.256$$
$$\sqrt{0.256} = .506 \ \frac{\text{MeV}}{c^2} \sim m_e c^2$$ (2)

5. Thomson's (1) (e/m) (1) measurement

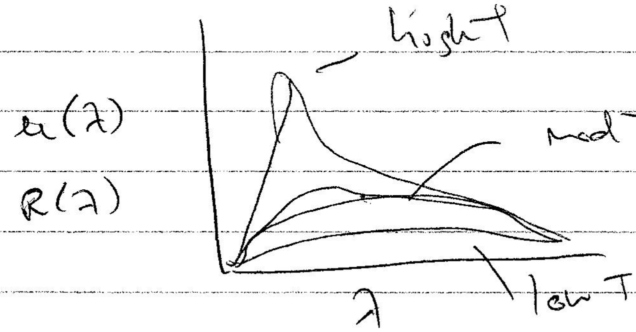
(3)



$\vec{B}$ applied ⊥ to $\vec{E}$ and $\vec{v}$ for finding velocity (1)

$$\boxed{v = \frac{E}{B}}$$ (1) (4)

6.



(2)

2

$\lambda_{max} T = \text{constant}$ Wein's displacement law

$R_{tot} = \sigma T^4$ Stefan Boltzman

$$u(\lambda) = \frac{8\pi}{\lambda^4} \frac{hc}{\lambda} \frac{1}{\exp\left(\frac{hc}{\lambda k_B T}\right) - 1}$$ Planck's BB dist law

$$u(\lambda) = \frac{8\pi}{\lambda^4} k_B T$$ Rayleigh Jean's

UV catastrophe was prediction of classical physics
(2) that $R(\lambda)$ or $u(\lambda)$ approaches infinity at small λ
or high ν

(1 Resolved by Planck's quantum hypothesis $\Delta E = nh\nu$

7. (2 Strong evidence for big bang theory of the universe.