# THE SCHOOL FOR EXCELLENCE
# UNIT 3 PHYSICS 2007
# COMPLIMENTARY WRITTEN EXAMINATION 1

## SECTION A – CORE STUDIES

### AREA OF STUDY 1 - MOTION IN ONE AND TWO DIMENSIONS

**QUESTION 1** 57.6 km/h

**QUESTION 2** Zero (she has reached terminal velocity).

**QUESTION 3** Accept between 460 – 490 m.

**QUESTION 4** 23.2 N

**QUESTION 5** 12 m/s

**QUESTION 6** Answer is B

**QUESTION 7** 5 m/s West

**QUESTION 8** 30 m East

**QUESTION 9** 10 m/s

**QUESTION 10** 2 seconds

**QUESTION 11** 48 m

**QUESTION 12** 23 degrees ($22.6^{o}$)

**QUESTION 13** Answer is A (air increases time of flight).

**QUESTION 14** $3.08 \times 10^{3}$ m/s

**QUESTION 15** $8.61 \times 10^{4}$ seconds (1 mark for $8.64 \times 10^{4}$)

**QUESTION 16** 0.22 N/kg

**QUESTION 17** Answer is E

## AREA OF STUDY 2 - ELECTRONICS AND PHOTONICS

**QUESTION 1**

$$V_{OUT} = \frac{R_2}{R_1 + R_2} \times V_{IN}$$

$$6 = \frac{6000}{R_1 + 6000} \times 8$$

$$R_1 = 2000\Omega$$

From the resistance – time graph 2 2 $k\Omega$ corresponds to $25^o C$.

**QUESTION 2**

$$V_{OUT} = \frac{R_2}{R_1 + R_2} \times V_{IN}$$

$$V_{OUT} = \frac{6000}{4000 + 6000} \times 8$$

$$V_{OUT} = 4.8\, volts$$

**QUESTION 3**

Switch the positions of the thermistor and the $6\ k\Omega$ resistor.

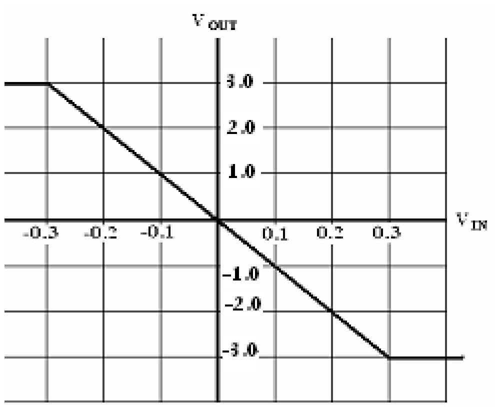
**QUESTION 4**

Replace the $6\ k\Omega$ resistor with a variable resistor with a range either side of $6\ k\Omega$.

**QUESTION 5** Answer is C

**QUESTION 6** Answer is D

**QUESTION 7**



**QUESTION 8**

This is an inverting amplifier because a rising positive input produces an increasing negative output. This would produce a wave inversion.

**QUESTION 9**

$V_B = V_E + 0.3 = 0.7 + 0.3 = 1.0V$

**QUESTION 10** Answer is B

**QUESTION 11**

With an amplification of 10, the change in voltage will be ten times $V_B$. This change will be a decrease in voltage because the extra current through the collector resistor will increase its potential difference.

Therefore an decrease of 1V meaning $V_c = 4V$

**QUESTION 12**

$$\Delta V_C = \Delta I_C \times R_C$$
$$1.0 = \Delta I_C \times 5000$$
$$\Delta I_C = 0.0002A = 200\mu A$$

$$A_I = \frac{\Delta I_C}{\Delta I_B} = \frac{200}{2} = 100$$

**QUESTION 13**

The graph shows that the photodiode is conductive when there is no voltage across the diode in lit conditions. Therefore there can be a maximum potential difference across the resistor equal to the supply voltage, i.e. 10 V.

Hence $I = \frac{V}{R} = \frac{10}{5 \times 10^5} = 2.0 \times 10^{-5}\ A \quad (or\ 20\mu A)$

**QUESTION 14**

In the previous question we saw that 20 microamps was the greatest current possible when the full potential difference of the supply was across the resistor. Therefore, the maximum distinguishable light intensity would be 4 $Wm^{-2}$ (Determined from graph).

**QUESTION 15**

At 1.0 $Wm^{-2}$ the photocurrent is 5 microamps.

Using Ohm's law we can establish the potential difference across the resistor;
$V = I \times R = 5 \times 10^{-6} \times 500 \times 10^3 = 2.5\text{V}$

$V_{OUT}$ is therefore $2.5V$.

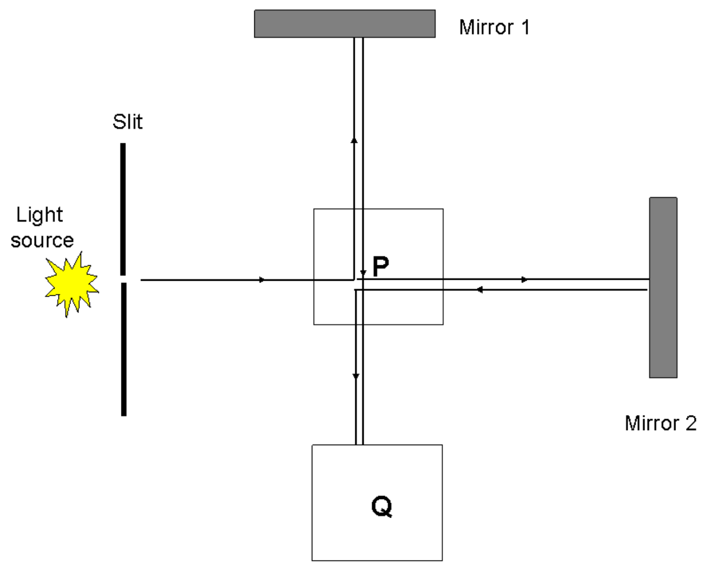
# SECTION B – CORE STUDIES

## DETAILED STUDY 1 - EINSTEIN'S SPECIAL RELATIVITY

**QUESTION 1** Answer is B

**QUESTION 2**

Correct direction = 1 mark
Correct start and finish points = 1 mark
Correct pathways = 1 mark




**QUESTION 3** Answer is C

**QUESTION 4** Answer is D

**QUESTION 5**

Earth observer = 50 years, spaceship observer = 44.2 years

**QUESTION 6**

$$\gamma = \frac{m}{m_o}$$

$$\frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = \frac{m}{m_o}$$

$$\frac{v}{c} = \sqrt{1-\left(\frac{m_o}{m}\right)^2} = \sqrt{1-\left(\frac{9.11\times10^{-31}}{2.09\times10^{-30}}\right)^2} = 0.9$$

$$v = 0.9c$$

**QUESTION 7**

$$\begin{aligned} E &= mc^2 \\ &= 2.09\times10^{-31}\times\left(3\times10^8\right)^2 \\ &= 1.88\times10^{-13}\,J \end{aligned}$$

**QUESTION 8**

$$\begin{aligned} Workdone &= E - m_o c^2 \\ &= 1.88\times10^{-13} - 9.11\times10^{-31}\times\left(3\times10^8\right)^2 \\ &= 1.06\times10^{-13}\,J \div 1.6\times10^{-19} \\ &= 0.66 MeV \end{aligned}$$

**QUESTION 9**

Determine the relative distance the muon travels as seen by the muon (2 marks).

$$\begin{aligned} L &= \frac{L_o}{\gamma} \\ &= 10\sqrt{1-(0.9995)^2} \\ &= 0.3km \end{aligned}$$

**Distance**

$$0.9995\times3\times10^8\,m/s\times2.2\times10^{-6}\,s = 660m > 300m$$

The muons see the Earth's atmosphere moving towards them at 0.995c and therefore observe a length contraction $\Rightarrow$ The atmosphere is only 300m thick rather than 10 km (1 mark).

Because the length has contracted, the muons can reach the surface within their short lifetime (1 mark).

**QUESTION 10**

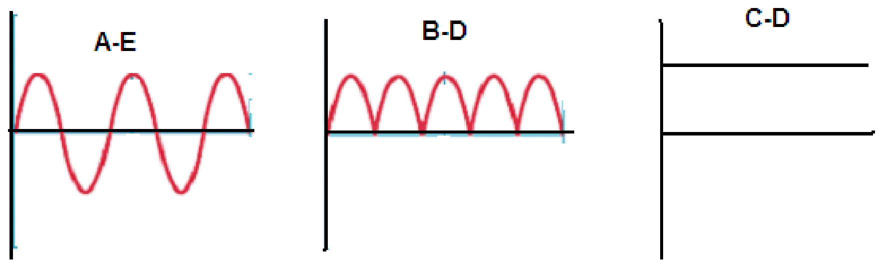
| | |
|---|---|
| Increase speed = Increase in relativistic mass . | 1 mark |
| Increase in mass = Increase in inertia $\Rightarrow$ More difficult to accelerate. | 1 mark |
| At $v = c$, mass is infinite and therefore cannot be accelerated. | 1 mark |

## DETAILED STUDY 2 - FURTHER ELECTRONICS

**QUESTION 1**

It is able to supply a constant DC voltage regardless of the load current (or resistance).

**QUESTION 2**




**QUESTION 3**

Peak voltage from transformer is $P_{RMS} \times \sqrt{2} = 17.0V$ .

After allowing for potential drop across two diodes (2 x 0.7 = 1.4V ) this becomes 15.6V

**QUESTION 4**

Peak voltage into VR is 15.6V, and with a ripple of 3.0V, the minimum voltage into the VR is 12.6V. The approximate average voltage into the VR is hence 14.1V. With an output voltage of 10V from the VR, the potential difference across this component is about 4.1V

Power = Potential difference x Current = 4.1 x 0.1 = 0.41W

**QUESTION 5** **Answer is** C

The second load resistor will double the current though the voltage regulator, but this will also increase the voltage ripple, hence lower the average voltage into the regulator. The consequence of both changes will be less than a doubling.

**QUESTION 6**

Voltage regulators switch off when overheated and turn back on again when cool.

**QUESTION 7**

Some possibilities include heat sinks, cooling fans, limiting the current.

**QUESTION 8**

$$R = \frac{V}{I} = \frac{4.0}{0.2} = 20\Omega$$

**QUESTION 9**

Current through LOAD $= \frac{V}{R} = \frac{6.0}{40} = 0.15\,amps = 150\,mA$

**The current through the zener is 50mA** (current through the dropping resistor less the current through the load).

**QUESTION 10**

P = V x I = 6.0 x 0.05 = 0.3W = 300mW.
This is less than the maximum allowable power so it is a suitable choice.

**QUESTION 11**

$500\,\mu F$

$\tau = 5 \times T_{SUPPLY} = 5 \times 0.02 = 0.1\,s$

$\tau = RC$

$\therefore C = \frac{\tau}{R} = \frac{0.1}{200} = 0.0005F = 500\,\mu F$

## DETAILED STUDY 3 - STRUCTURES AND MATERIALS

**QUESTION 1** Answer is D

This is where concrete is under tension.

**QUESTION 2**

The reinforcing provides strength where the concrete is under tension. Although iron and steel are both stronger than concrete under tension, steel has a greater tensile strength than iron.

**QUESTION 3** Answer is B

**QUESTION 4** 120 N

**QUESTION 5** 580 N

**QUESTION 6** Answer is C

**QUESTION 7**

**Strength** refers to the maximum stress a material can withstand.

**Aluminium** has a greater maximum stress and is therefore stronger than copper.

**Toughness** refers to the ability of a material to absorb energy under stress, which is indicated by the area under its stress-strain graph.

**Aluminium** has a greater area under its graph indicating that it is tougher than Copper.

**QUESTION 8** $2.0 \times 10^{11}$ Pa

**QUESTION 9** 9000 J/$m^3$

**QUESTION 10** 0.3 mm