THE SCHOOL FOR EXCELLENCE
UNIT 3 PHYSICS 2009
COMPLIMENTARY WRITTEN EXAMINATION 1

SECTION A – CORE STUDIES

AREA OF STUDY 1 - MOTION IN ONE AND TWO DIMENSIONS

QUESTION 1

At terminal velocity the force of air resistance (up) is equal in magnitude to the weight force down. Therefore the force of air resistance is 2.25 N up (or 2.21 N up if using g= 9.8).

[1 mark] for recognising $|mg| = |F_{air}|$
[1 mark] for 2.25 N
[1 mark] for direction = up

QUESTION 2

$\Delta p = F\Delta t$ $\quad F_{ave} = \frac{\Delta p}{\Delta t} = \frac{13.5}{0.25}$ = 54 N

[1 mark] for correct substitution into formula
[1 mark] for 54 N
[1 mark] for direction = up

QUESTION 3

$\Delta p = m\Delta v$
$\Delta p = m(v-u)$

Take upward as positive: $13.5 = 0.225 (v - -28)$

$$\frac{13.5}{0.225} = v + 28$$

$$60 = v + 28$$

$v = 60 - 28$ = 32 m/s upward

[1 mark] for correct substitution into formula
[1 mark] for 32 m/s
[1 mark] for direction = upward

QUESTION 4

C is the correct option. Speed does not take direction into account.
The other 4 statements are essentially correct.

QUESTION 5

Friction is providing the centripetal force.

$$F_c = \frac{mv^2}{r} = \frac{0.024 \times 50^2}{0.08} = 750\ N$$

[1 mark] for correct substitution into formula
[1 mark] for 750 N

QUESTION 6

B is the correct option.
The stone moves off tangential to its circular path.

QUESTION 7

Andrew is correct (g = 2.45 N/kg). [1 mark]
The gravitational field strength is inversely proportional to the square of the radial distance according to the equation:

$$g = \frac{GM}{r^2}$$ [1 mark]

When the radial distance is doubled, the gravitational field strength will be a quarter of its value at the surface of the Earth.

QUESTION 8

The skater's initial vertical velocity is given by $u_y = 4.8\sin 28° = 2.25$ m/s. [1 mark]

Using this and the formula v = u + at gives: 0 = 2.25 – 10t [1 mark]

t = 0.23 s [1 mark] for the time to reach the highest point.

QUESTION 9

Total time of flight = 2 x 0.23 = 0.46 s

Horizontal velocity = $u_x = v_x = 4.8\cos 28° = 4.238$ m/s [1 mark]

Therefore the attained range will be 0.46 x 4.238 = 1.95 m [1 mark] and given that the ramps are 2.0 m apart, he doesn't make it. [1 mark]

QUESTION 10

Gravity acts down and air resistance acts to the left (opposing his motion) so the best answer is B. Air resistance is significant in comparison with the weight force.

QUESTION 11

The correct answer is A.

QUESTION 12

According to the equation: $T = \sqrt{\frac{4\pi^2 R^3}{GM}}$ [1 mark] if the orbital radius is the same for both objects then the period will be greater for the lighter central mass (M).

[1 mark] for explanation.

QUESTION 13

According to: $v = \sqrt{\frac{GM}{R}}$

$v = \sqrt{\frac{6.67\times10^{-11}\times1.2\times10^{21}}{3.5\times10^{5}}}$ [2 marks] = 478 m/s [1 mark]

QUESTION 14

Using Pythagoras yields Δv = 4.24 m/s [1 mark] in the south-westerly [1 mark] direction.

QUESTION 15

$\Delta p = m\Delta v$ = 14 x 4.24 = 59.4 kgm/s [1 mark] south-west. [1 mark]

AREA OF STUDY 2 - ELECTRONICS AND PHOTONICS

QUESTION 1

$$\frac{1}{R_p} = \frac{1}{30} + \frac{1}{(30+30)} = \frac{3}{60}$$

$$R_p = 20\Omega$$

$$R_{tot} = 30 + 20 = 50\Omega$$

QUESTION 2

$$I = \frac{V}{R} = \frac{12}{50} = 0.24A$$

QUESTION 3

G1 has the greatest potential difference and current of all globes. As P=IV, G1 has the largest power and therefore the greatest brightness.

QUESTION 4

Answer is C. An open switch at point Y will redirect all the current through G2 and increase the brightness.

QUESTION 5

Answer is A. As all the current from the battery passes through point W, an ammeter at this point would measure the current from the battery.

QUESTION 6

1000 Ω

QUESTION 7

1.8 – 1.9 V

QUESTION 8

At 10mA, LED has a PD of 1.7 V, the thermistor has a PD of $V = IR = 10 \times 10^{-3} \times 1000 = 10V$
Supply Voltage = 10+1.7 = 11.7V

QUESTION 9

No as temp decreases, R increases and I decreases. Therefore LED turns off.

QUESTION 10

Answer is B.

QUESTION 11

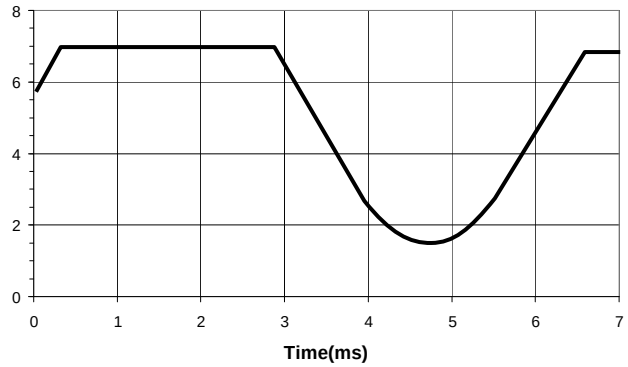
Non-inverting – as the gradient is positive.

QUESTION 12

Gradient of graph: $\frac{rise}{run} = \frac{6.5}{0.14} = 46$

QUESTION 13

Axes labelled to 7V, clipping at 7V corresponding over the time intervals of 0.3-2.8 ms and 6.5-7 ms. Minimum at 1.3 V. Also show the output signal as non-inverted.



QUESTION 14

20μA

SECTION B – CORE STUDIES

DETAILED STUDY 1 - EINSTEIN'S SPECIAL RELATIVITY

QUESTION 1 Answer is B

An inertial frame of reference is one which is not accelerating

QUESTION 2 Answer is C

Galileo postulated that all velocities are relative to the observer.

QUESTION 3 Answer is C

Given that X sees flashes travelling toward him with speed of light, as simultaneous. Observer Y, moving relative to X, will be in a different position from X when flashes arrive, so for Y they will *not* arrive simultaneously. The one coming from the front of the train will arrive first.

QUESTION 4 Answer is B

For X: $\frac{100}{\gamma} = \frac{100}{1.15} = 87\,m$

QUESTION 5 Answer is A

According to X the scorch marks on the station will be equal to the length of the observed train which is 87m. According to Y these marks will be length contracted.

$$\frac{100}{\gamma} = \frac{87}{1.15} = 76m$$

QUESTION 6 Answer is D

$t = \gamma t_o$; $\gamma = 2.3,$ therefore 2.3 revolutions

QUESTION 7 Answer is C

The half-life as measured by the laboratory observer = 3.1 x 10^{-6} x 2.3 = 7.1 x 10^{-6}s, Therefore distance travelled = speed x time = 0.9c x 7.1 x 10^{-6} = 1920m

QUESTION 8 Answer is C

$$\gamma = \frac{1}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}} = \frac{1}{\sqrt{1-0.97}} = 4.1$$

$$m = \gamma m_o = 4.1 \times 9.1 \times 10^{-31} = 3.7 \times 10^{-30}\ kg$$

QUESTION 9 Answer is C

$KE = (\gamma - 1)m_o c^2$ = (4.1 – 1) 9.1 x 10^{-31} x (3 x 10^8)^2 = 2.51 x 10^{-13}J

QUESTION 10 **Answer is B**

Dependent on the relativistic mass and velocity of the object.

QUESTION 11 **Answer is A**

No detectable velocity difference from light reflecting off each mirror

QUESTION 12 **Answer is A**

Travel time to the star system in Earth's reference frame = $\frac{8.4}{0.95} = 8.84 \, years$

QUESTION 13 **Answer is B**

$$\gamma = \frac{1}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}} = 3.2$$

Time in earth's reference frame would be 2 x 8.84 = 17.7 years

$T_{astronaut} = \frac{17.7}{\gamma} = \frac{17.7}{3.2} = 5.6 \, years$

DETAILED STUDY 2 - FURTHER ELECTRONICS

QUESTION 1 **Answer is B**

Time constant = R C =200 x 100 x 10^{-6} = 0.02s = 20ms

QUESTION 2 **Answer is A**

From the graph the time constant is found to be about 10ms.
Resistance = time constant / capacitance = 10 x 10^{-3} / 100 x 10^{-6} = 100 ohm

QUESTION 3 **Answer is B**

The supply to the resistor is half-wave rectified.

QUESTION 4 **Answer is D**

When the diode is forward biased there will be a small constant forward potential across it. In the other half of the cycle when the diode is reverse biased, it will have the full supply potential (as though it was an open switch).

QUESTION 5 **Answer is C**

To be deemed regulated it must provide constant output voltage over a range of load and supply voltages. In a voltage divider V OUT is dependent on the total resistance across it.

QUESTION 6 **Answer is G**

Both C and D result in current passing the same direction through the load

QUESTION 7 **Answer is C**

Adding a second LOAD doubles the current. Since $V_{RIPPLE} \propto I_{LOAD}$,
then ripple becomes double.

QUESTION 8 **Answer is A**

Since $V_{RIPPLE} \propto \frac{1}{C}$, then tripling capacitance by adding two additional capacitors would reduce ripple to one third of the original.

QUESTION 9 **Answer is A**

The current through the LOAD can be determined from $I_{LOAD} = \frac{V}{R} = \frac{6}{120} = 0.05A$

The average voltage supplied to the regulator is approximately 11V ($\frac{V_{MAX} + V_{MIN}}{2} \approx 11V$

The potential drop across the regulator is 11 – 6 = 5.0V
P_{LOSS} = V x I = 5.0 x 0.05 = 0.25W

QUESTION 10 **Answer is A**

The trough of the ripple voltage crosses into the dropout zone of the voltage regulator resulting in a reduced output voltage from the IC regulator.

QUESTION 11 **Answer is B**

$I_{50\Omega} = \frac{V}{R} = \frac{3}{50} = 0.06\,A$ and $I_{300\Omega} = \frac{V}{R} = \frac{6}{300} = 0.02A$

$I_{ZENER} = I_{50\Omega} - I_{300\Omega} = 0.06 - 0.02 = 0.04A$

QUESTION 12 **Answer is B**

The total current is unchanged at 0.06A, and with the switches closed each resistor draws 0.02A, resulting in only 0.02A flowing through the zener diode.

QUESTION 13 **Answer is A**

With switch 1 open all current is directed through the zener diode.

$P_{ZENER} = 6.0 \times 0.06 = 0.36W$ which exceeds the diode power rating.

DETAILED STUDY 3 - STRUCTURES AND MATERIALS

QUESTION 1 **Answer is B**

Greatest stress.

QUESTION 2 **Answer is A**

Largest gradient = stiffest

QUESTION 3 **Answer is C**

Area under graph: $\frac{1}{2}300\times10^{6}\times\frac{0.2}{100}=300\times10^{3}\,J/m^{3}$

QUESTION 4 **Answer is B**

QUESTION 5 **Answer is D**

Gradient : $\frac{rise}{run}=\frac{200\times10^{6}}{0.4\times10^{-2}}=50\times10^{9}\,Pa$

QUESTION 6 **Answer is B and C**

Concrete is weaker under tension and needs to be reinforced at points b and c.

QUESTION 7 **Answer is B**

QUESTION 8 **Answer is C**

Take torques at the wall.

$\Sigma\tau=0$

$2000\times1.5+650\times3=F\times2$

$F=2475N$

QUESTION 9 **Answer is B**

$\sum F=0$

$F_{w}+2475-2000-650=0$

$F_{w}=175$

QUESTION 10 **Answer is D**

$\%strain=\frac{\Delta l}{l}\times100=\frac{0.05}{50}\times100=0.1$

QUESTION 11 **Answer is B**

$F=\sigma A=500\times10^{6}\times100\times10^{-6}=50\times10^{3}\,N$

QUESTION 12 **Answer is A**

$$\varepsilon = \frac{\sigma}{E} = \frac{500 \times 10^6}{200 \times 10^9} = 0.0025$$

QUESTION 13 **Answer is D**

Steel is stiffer, having the larger Young's modulus.