Focus study group

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PHYSICS

Written examination 1

2011

Solutions

Area of study 1 – Motion in one and two dimensions.

Question 1

Total downward force is (70 + 10)g = 80. Constant velocity so total upwards force is also 80g = **800N**.

2 marks

Question 2

Total tension in the ropes must balance the persons weights so total tension =70g **700N**.

2marks

Question 3

$v^2 = u^2 + 2ax \rightarrow v^2 = 10^2 + 2(10)(20)$

$v = \mathbf{22.4\ ms^{-1}}$

2 marks

Question 4

$a = \frac{v^2}{r} \rightarrow r = \frac{v^2}{a} = \frac{56^2}{5(10)} = \mathbf{63m}$

2 marks

Question 5

Constant circular motion so net force is towards the centre of the circle, so **A** is correct.

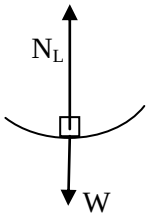
2 marks

Question 6

Lowest point

$N_L - W = \frac{mv^2}{R}$

$N_L = \frac{mv^2}{R} + W$



Highest point

$N_T + W = \frac{mv^2}{R}$

$N_T = \frac{mv^2}{R} - W$

So, $N_L > N_T$

Normal reaction = apparent weight so the pilot feels heaviest at the lowest point.

3 marks

Question 7

$v^2 = u^2 + 2ax$

$a = \frac{v^2 - u^2}{2x} = \frac{40^2}{2(0.6)} = \mathbf{1.33 \times 10^3\ ms^{-2}}$

2 marks

Question 8

F = ma = 0.057 x 1.33 x 10^3 = 76 N

2 marks

Question 9

Horizontally:

$v = \frac{x}{t}$

$t = \frac{x}{v} = \frac{30}{40} = 0.75\ s$

Vertically:

$x = ut + \left(\frac{1}{2}\right)at^2$

$= 0 + \left(\frac{1}{2}\right)(10)(0.75)^2$

$= \mathbf{2.8\ m}$

4 marks

Question 10

Speed just before landing:

$v^2 = u^2 + 2ax$

$= 0 + 2(10)2$

$v = 6.32\ ms^{-1}$

Momentum just before landing:

$P = mv$

$= 60 \times 20 \times 10^6 \times 6.32$

$= \mathbf{7.59 \times 10^9\ kgms^{-1}}$

2 marks

Question 11

$P_{INITIAL} = P_{FINAL}$

$7.59 \times 10^9 = (m + M)V$

$= (60 \times 20 \times 10^6 + 5.98 \times 10^{24})V$

$V = \mathbf{1.27 \times 10^{-15}\ kgms^{-1}}$

3 marks

Question 12

1 x 10^{-15} m is about the diameter of a proton. So the Earth moves an incredibly small distance in 1 second. We could not detect this movement. (Lee is correct)

1 mark

Question 13

WD = (F x d) + (mgh)

= (200 x 15) + (80 x 10 x 2.0)

= **11 000 J**

3 marks

Question 14

KE lost = mgh = 80 x 10 x 2 = **1600 J**

2 marks

Question 15

For a spring: $PE = \left(\frac{1}{2}\right) k\, x^2$

$$k = \frac{2 \times PE}{x^2} = \frac{2\,(1600)}{0.2^2} = \mathbf{80\,000\ Nm^{-1}}$$

3 marks

Question 16

Relevant equation is: $F = \frac{GMm}{r^2}$

If *m* is decreased by a factor of 1/10, F will decrease by a factor of 1/10.

If the altitude is doubled then the radius is tripled as altitude is measured from Earth's surface. This will further reduce the force by a factor of $(1/3)^2 = 1/9$

So, total effect is 1/10 x 1/9 i.e. **Force on satellite = 1/90 Force on rocket-ship.**

2 marks

Question 17

Use $F = \frac{GMm}{r^2}$ and $F = \frac{v^2}{r}$ to get $\frac{GM}{r} = \frac{v^2}{r}$ or $v^2 = \frac{GM}{r}$

$$v^2 = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{3 \times 6.37 \times 10^6}$$

v = **4.6 x 10^3 m s^{-1}**

3 marks

Area of study 2 – Electronics and photonics

Question 1

$V = R\,I$

$I = \dfrac{V}{R} = \dfrac{(1.5 - 0.7)}{10} = 0.08\ A = \mathbf{80\ mA}$

2 marks

Question 2

The voltage drop across the resistor is still 1.5 – 0.7 = 0.8V. So the current is still **80 *mA***

Question 3

The three diodes in series require a total voltage of 3 x 0.7 = 2.1 V to switch on, but only 1.5 V is available. So, diodes will not switch on so **zero current through the resistor.**

2 marks

Question 4

The graph suggests a value around **1.5^0C** (1.4^0C to 1.6^0C acceptable)

1 mark

Question 5

<u>The long way</u>

$V_O = \dfrac{R_{TH}}{(R_{TH} + R)} \times V_{IN}$

$80 = \dfrac{200k}{(200k + R)} \times 240$

$R = \mathbf{400k\Omega}$

<u>The short way</u>

Thermistor V:Resistor V = 80:160 = 1:2

Thermistor R:Resistor R = 200K:x

Ratios must be the same so x = **400kΩ**

3 marks

Question 6

NO

1 mark

Question 7

Voltages must add up to 240V

Same current thru' each resistor so larger V across the larger resistance (V = RI).

As the temperature rises the resistance of the thermistor decreases so the voltage across the thermistor decreases so the frige switches off at higher temperatures. This is the reverse of what should happen!

3 marks

Question 8

Electrical waves with the same frequency as sound waves (20 – 20kHz) can pass along wires but not along optic fibre. High frequency light waves ($\approx 10^{14}$ Hz) can pass through optic fibre. So the amplitude of laser light (which can pass through optic fibre) is varied with a frequency to match that of sound waves. This way, a wave of the frequency of sound waves can pass through optic fibre. This is called modulation.

3 marks

Question 9

Sound waves = B Modulated light waves = D

2 marks

Question 10

Light to electrical, could be Light Dependent Resistor or photodiode or phototransistor or . . . .

1 mark

Question 11

V_{OUT} decreases as V_{IN} increases so it is a **Inverting amplifier.**

1 mark

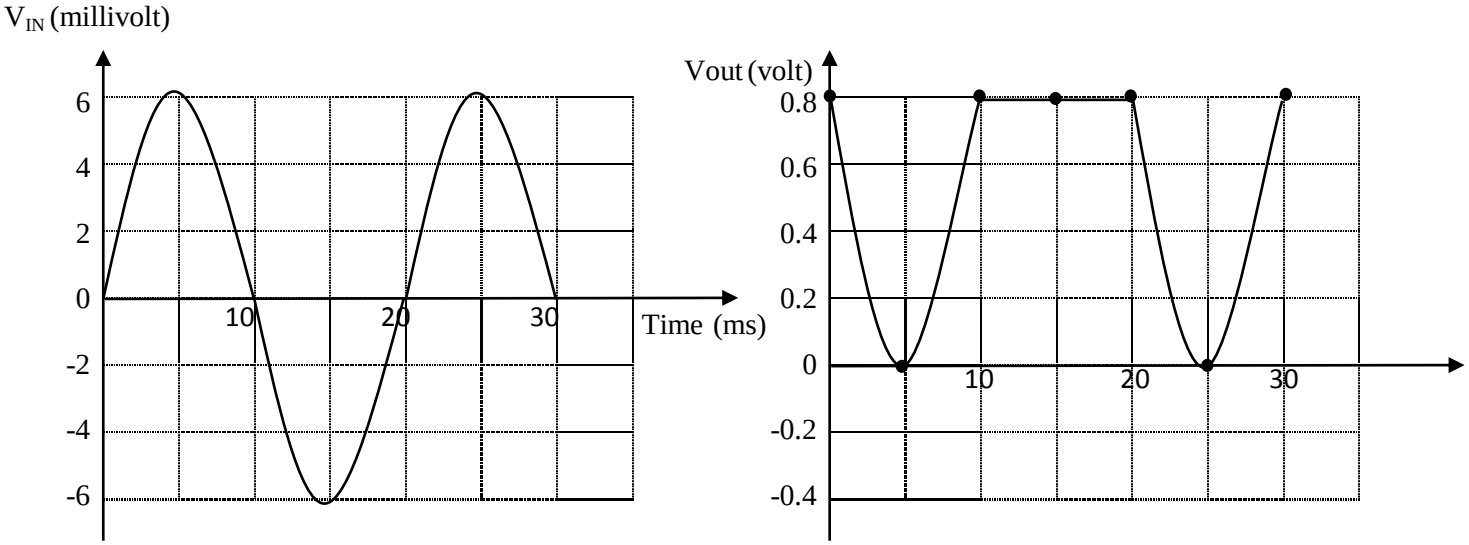
Question 12

$$Gain = gradient = \frac{rise}{run} = \frac{0.8}{6 \times 10^{-3}} = \mathbf{133}$$

Note: No units and negative sign is not necessary.

2 marks

Question 13



3 marks

Detailedstudy1 – Einstein's special relativity

Question 1 **C:** A, B & D were important discoveries, they were not the result of the M &M exp

Question 2 **A:** Inertial F.O.R. is a non-accelerating F.O.R. so bodies under zero net force either remain at rest or . . . .

Question 3 **D:** It is the relative motion that is important. Stanley's case will look shorter to Leah and Leah's case will look shorter to Stanley. Leah's case is in the same frame of reference as herself so it appears 1.0 m long to her. Same with Stanley's case.

Question 4 **B:** Straight from the formula sheet. Note; L_O = 1.0 m

Question 5 **C:**

Question 6 **B:** The speed of light in all frames of reference is *c*.

Question 7 **B:** The scientists see the electrons travelling at 0.9999*c* for 3000m. (v = d/t)

Question 8 **D:** The electrons see the SLAC speeding backwards at 0.9999*c*. Use $L = L_O / \gamma$

Question 9 **D:** The "thinks" the SLAC is 42.4 m long. So time to travel 42.4 m @ 0.9999c is given by: $v = \frac{d}{t} \rightarrow t = \frac{d}{v} = \frac{42.2}{0.9999c} = 1.41 \times 10^{-7}\ s$ (Note: This Answer 7 / γ)

Question 10 **D:** Use $m = m_O\gamma$, m_O is given so find m.

Question 11 **A:** Definition

Question 12 **D:** $E_K = (\gamma - 1)m_Oc^2$

Detailed study 2 – Materials and their use in structures

Question 1 **A:** Linear elastic region where there is a linear relationship between stress and strain.

Question 2 **D**: Ultimate tensile strength is the maximum stress reached by the material.

Question 3 **B:** Yield strength point or yield point is where the relationship between stress and strain is no longer linear. The material starts to deform.

Question 4 **A:** Breaking strength is where the material breaks. (Almost obvious!)

Question5 **C:** Young's modulus is the gradient of the linear section

Question 6 **A:** 40MPameans stress = 2%

$$\frac{\Delta X}{L} = \frac{2}{100}$$

$$\Delta X = 2\ cm$$

So new length = 100 + 2 = 102 cm

Question 7 **D:** $\sigma = \frac{F}{A} = \frac{mg}{A}$

$$m = \frac{A \times \sigma}{g} = \frac{\pi \times r^2 \times \sigma}{g} = \frac{\pi \times (0.01)^2 \times 20 \times 10^6}{10} = 628\ kg$$

Question 8 **B:** The arch works by redirecting compression forces to the ground. Stone is strong under compression.

Question 9 **C:** The left half of the slab tends to sag in the middle so the lower side is under tension. Concrete is weak under tension so put reinforcement here. The right side tends to sag at point Y so the upper side is under tension. Put reinforcement here also.

Question 10 **B:** Forces up = forces down (C & D look a bit like torque equations but they are wrong!)

Question 11 **C:** As the load increases the crane will rotate clockwise and so the wheels to the left of the diagram will lift off the ground, so N_1 will reduce to zero.

Question 12 **B:** Clockwise τ = Anticlockwise τ

W x 4 = w x 16

200 x 4 = mg x 16

m = 5.0T

Detailed study 3 – Further electronics

Question 1 **A:** $V_{rms} = \frac{V_{peak}}{\sqrt{2}} = \frac{0.4}{\sqrt{2}} = 0.28$ V

Question 2 **C:** $f = \frac{1}{T} = \frac{1}{0.2 \times 10^{-3}} = 5000\ Hz$

Question 3 **A:** $P = \frac{V^2}{R} = \frac{0.5^2}{25 \times 10^3} = 1.0 \times 10^{-5} = 0.01\ mW$

Question 4 **D:** $\frac{V_o}{V_i} = \frac{N_o}{N_i} \rightarrow \frac{0.5}{240} = \frac{300}{N_i} \rightarrow N_i = 144\,000$

Question 5 **C:** A single diode acts as a half-wave rectifier

Question 6 **B:** $\tau = R \times C = 25 \times 10^3 \times 8.0 \times 10^{-6} = 0.2s$

Question 7 **C:** Period of input signal is 0.2s i.e. 4 horizontal grid spacings, that cuts out B & D. Time constant is 0.2s so the voltage will drop approx. 63% between each peak.

Question 8 **B:** The 12V regulator will maintain an output of 12V provided the input is greater than this

Question 9 **D:** The 12 V regulator will only maintain a 12 V output if the input is greater than 12 V. Otherwise the output is the same as the input (you can't get something for nothing!)

Question 10 **D:** First, since the input is DC the CRO will just show a horizontal line, not very informative. Second, there are good CROs and there is junk

Question 11 **A:** Closing SW1 will charge the capacitor, opening SW1 will allow the capacitor to hold its charge, closing SW2 will allow the capacitor to discharge through the resistor

Question 12 **B:** $\tau = R \times C = 200 \times 10^3 \times 50 \times 10^{-6} = 10s$ So it takes 10s to lose 63% of its charge (37% remaining). So the voltmeter reads 3.7 volt.