**2014**

#### VCE

**Physics**

**Trial Examination**

**Suggested Answers**

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**Area of Study - Motion in one and two dimensions**

**Question 1**

**a.** *m* = 1.40 kg, *h* = 1.50 m, *g* = 10 ms-2

 Potential energy initially = *mgh* = 1.4 × 10 × 1.5 = 21 J

 Kinetic energy finally = ½ mv2 = 21 J *(1)*

 therefore *v = √ (2Ek / m)* = √ (2 × 21/ 1.4) = 5.48 ms-1. *(2)*

**b.** Work done crossing the floor = *Fx* = 1.5 × 8.0 = 12.0 *(1)*

 Kinetic energy on reaching the barrier = 21 – 12 = 9.0 *(2)*

 compression distance = *√ (2 Espring / k)* = √ (2 × 9 / 100) = 0.424 m *(3)*

**c.** B *(2)*

The simplest check on this answer, is that the end points of the graph are fixed,

(*v* = 3.6 ms-1 when *x* = 0, v = 0 when *x* = 0.42 m)

but the shape may be in doubt. At half the final compression, only 0.25 of the kinetic energy has been converted to spring potential energy. So the velocity must be higher than half the original to give this balance of energies. Hence a downward curve, getting steeper.

Alternatively

*Et = Ek + Es*

*Et = ½ mv2 + ½ kx2*

*½ mv2 = Et – ½ kx2*

*v2 = 2/m(Et – ½ kx2)*

*v = √ (2/m(Et – ½kx2))*

**d.** **vST = vSg + VgT**describes the relative velocity in vector form.

 **vSg** (student relative to the ground) = 1.2 (towards the spring, away from the ramp)

 **vTg** (trolley relative to the ground) = 2.1 (towards the ramp, from the spring)

 = - 2.1 (towards the spring, away from the ramp)

 The two vectors have to be expressed in the same direction)

 Therefore **vgT** = 2.1 (towards the spring, away from the ramp)

 **vST = vSg + VbT** = 1.2 + 2.1 = 3.3 ms-1 *(1)* (towards the spring, away from the ramp) *(1)*

(either phrase)

 or **vST** = - 3.3 ms-1 *(1)*  (towards the ramp, from the spring) *(1)* (either phrase)

 This answer just reverses the directions used to define the vectors.

**Question 1 (continued)**

**Question 2**

**a.** *uy* = 7 × sin 60° = 6.06

 *vy* = 0

 *h* *(above shooting point) =uy2/(2g)* = 6.062 / 2 / 10 = 1.84 *(1)*

 *h above the floor* = 1.9 + 1.84 = 3.74 *(2)*

**b.** *ux* = 7 × cos 60° = 3.5

 *t (for ball to reach the distance 3.42 m)* = *x/v* = 3.42/3.5 = 0.977 s *(1)*

 *h (at this time)* = 6.06 × 0.977 – ½ × 10 × 0.9772 = 1.15 *(1)*

 *h (above floor)* = 1.9 + 1.15 = 3.05 m *(1)*

 The ball passes through the hoop.

or by parabola solution

 *y = x tanθ – gx2 / (2V2 cos2θ)* taking the origin at throwing point

 y = 3.42 × tan60° - 10 × 3.422 / 2 / (3.5 2)

 = 1.149

 add to height 1.9, h = 3.05 m

Area of Study - Motion in one and two dimensions

**Question 3**

**a.**



 *(1)* for each force correctly located and directed, titles are not needed.

 maximum *(1)* if not located correctly

**b.** D *(1)*

**c.** net force must be centripetal force to have circular motion *(1)*

must be toward the centre of the circle *(1)*

**d.** *g* = 10 ms-2, *R* = 0.25 m

*a/g = tan A*, *a* = 10 × tan 30° = 5.77 *(1)*

*v12/R* = a, so *v1 = √ (aR)* = √(5.77 × 0.25) = 1.20 = 1.2 ms-1  *(2)*

**Question 4**

**a.** *gAres* = 0.9N kg-1, *f* = 2 rpm = 2/60 = 0.0333, *T* = 1/0.03333 = 30 s, *R*=?,

 *g = 4π2R/T2, R = gT2/ 4 / π2* = 0.9 × 302 / 4 / π2 (1) = 20.5 m *(2)*

**b.** outer wall is the floor *(1)*

 It can provide a centripetal force to maintain a circular motion *(1)*

 This force is centred, normal support will be inward so and the space travellers will feel

 down is outward. *(1)*

**c.** *T* = 1.6 × 104 s, *R* = 6.5 × 106 m, *G*= 6.67 × 10-11, *mM = ?*

 *GmM / 4 / π2 = R3 / T2,* so *mM = 4π2R3 / T2 / G*

= 4π2 (6.5 × 106)3 / (1.61 × 104)2 / 6.67 × 10-11 *(1)*

 = 6.271 × 1023 = 6.27 × 1023 kg *(2)*

**d.** Both the travellers and the spacecraft have the same acceleration in orbit around Mars

 The force for this is provided by Mars gravity *(1)*

There is no reaction force between the spacecraft and the travellers so they experience apparent weightlessness. *(1)*

**e.** *mL* = 220 t = 2.2 × 105 kg, potential energy change = area under the graph,

 square area = 0.5 × 106  (m) × 0.5 (N kg-1) = 2.5x105 J kg-1  *(1)*

 squares count = 22

 *E* = 22 × 2.5 × 105 × 2.2 × 105 = 1.21 × 1012 = 1.2 × 1012 J *(2)*

Allow answers with 23 squares full marks

1. only for 5.5 × 106 J (ignores mass of the Lander)



**Study Design References:**

Apply gravitational field and gravitational force concepts, *g = GM/r2* and *F = GM1M2/r2*.

Apply the concepts of weight (*W=mg*), apparent weight (reaction force, *N*), weightlessness (*W=0*) and apparent weightlessness (*N=0*)

**Area of Study - Motion in one and two dimensions**

**Question 5**

**a.** 120 t = 1.2 × 105 kg added to each truck, in *T* = 40 s, *L* = 10 m, *vy* = 4.0 ms-1.

 each load, *m* = 1.2 × 105 / 40 = 3000 kg is added in 1.0 s *(1)*

*I = Δp = mΔv* = 3 × 103 × 4 = 1.2 × 104 Ns  *(2)*

**b.** horizontally the 3000 kg has zero momentum, so this must be added with *vx* = 0.25 ms-1

*I = Δp = mΔv* = 3 × 103 × 0.25  *(1)* = 750 Ns, so *F* = 750 N *(2)*

**c.** This only requires the analysis of the last truck.

 *Wdown slope* = (1.2 × 105 + 9.0 × 103) × 10 × sin 1° = 22513 *(1)* down

 *Ffriction* is up the slope

 a = 0 so *Fnet downslope* = 22513 – 10000 = 12513 N *(2)*

 *F by the last truck on the second last* = 12.5 = 13 kN down slope  *(3)*

**Question 6**

**a.** *D* = 4.5 m, *R* = 2.25m, *f* = 10 turns per min so *T* = 60/10 = 6.0 s

 *a = 4π2 R/T2*= 4π2 × 2.25/62  *(1)* = 2.47 = 2.5 ms-2 *(2)*

**b.** *W = mg + ma =* 5 × 10 + 5 × 2.47 *(1)* = 62.3 = 62 N  *(2)*

**Question 7**

**a.** *R1* = 1.8 kΩ, *R2* = 2.2 kΩ

 *Vx* *= Vsupply × R2 / (R1+ R2)* = 6 × 2.2 / (1.8 + 2.2)  *(1)* = 3.3 V  *(2)*

**b.** *RB* = (7.5 + 8.5) = 16 kΩ

 *RA* = 1.8 + 2.2 = 4 kΩ

 *Reff* = 1 / (1/4 + 1/16)  *(1)* = 3.2 kΩ *(2)*

**c.** B *(2)*

 if *R1/R2 = R3/R4* then *Vx = Vy.*

 Current will only flow if there is a voltage difference.

**Question 8**

**a.** *R Th* =2000 Ω (from the graph)  *(1)*

**b.** *Vswitch* = 4.0 V

 so *Vsupply × RTh  / (R + RTh) = Vswitch*

 *R =* 6 × 2000 / 4 – 2000 = 1000 Ω  *(2)*

*or VR / V switch = R / R Th*

 2 / 4 = *R* / 2000

 R = 1000 Ω

**c.** B *(1)*

**d.** For thermistor B, if Temperature rises, so does R, so *Vswitch* rises in the original circuit,

 so it needs a design like B or D *(1)*

 At – 4 °C, the resistance is (still) 2000 Ω

 *Vswitch* = 4 = 6 × 2000/(2000 + R)

 *R* = 4000 Ω  *(1)*

 Hence circuit B.

**Question 9**

**a.** *Vd* = 2.2 V, *I* = 18 mA = 0.018 A, *Vsupply* = 22 V

 *R* = (22 – 2.2) / 0.018  *(1)* = 1100 = 1.1 kΩ *(2)*

**b.** at 1.5 Wm-2, the *Ipc* = 6 μA  *(1)*

 *R* = 1.2 × 106

 *VR = IR* = 6 × 10-6 × 1.2 × 106 = 7.2 V  *(2)*

**c.** Modulated light wave (1) A  *(1)*

Only waves A, B and E look modulated. They all have a high frequency wave with a modified outline. However B lacks the negative amplitude of the wave.

Wave A has the envelope shape of the data wave superimposed on its upper and lower values, amplitude modulating it. Its brightness does not need to go to zero.

Wave E has its zero brightness at time 1 and then can’t represent the negative side of the data wave.

The envelope of this wave is not a smooth curve like the data.

Brightness (II) D *(1)*

Wave C apparently is two waves, which makes no sense at all.

F goes negative and brightness cannot.

D is always positive and looks like the data wave, just transposed upwards.

**d.** D *(1)*

The photo-diode current can only have one direction of flow and must have the same shape as the original data if the transfer was of high fidelity. Only D has this property.

This wave differs from the data only by amplitude and being vertically transposed.

**Question 10**

**a.** *f* = ?

 *T* = 50 ms, so f = 1000/50 = 20 Hz *(1)*

**b.** *Av = ΔVout / ΔVin* = 6V / 200 mV  *(1)* (or any other linear section) = 6000 / 200 = 30  *(2)*

**c.**



 frequency must be unchanged for full marks

 non-inverting *(1)*

 clipping at 8V  *(1)* and -4 V  *(1)*

**Area of Study - Electric Power**

**Question 11**

**a.** Vertical component of the Earth’s field = 60 μT at 70° = 60 sin 70° *(1)*  = 56 μT *(2)*

**b.** bottom of the magnet is “N” *(1)*

 Earth’s component is up, so bar magnet field must be down coming out of N, (using vector addition to zero) , opposing the upward vertical component of the Earth’s magnetic field. *(1)*

**Study Design Reference:**

Apply a vector field model to magnetic phenomena including shapes and directions of fields produced by bar magnets, and by current-carrying wires, coils and solenoids.

**Question 12**

**a.** *Vpp = VRMS × 2√2* = 85 × 2 × 1.41 *(1)* = 240 V*(2)*

**b.** *R = V2 / P* = 2302 / 1500 = 35.27 Ω *(1)*

 *P = V2 / R* = 852 / 35.27 = 205 W *(2)*

**Question 13**

**a.** D *(1)*

**b.** At D, perpendicular to the magnetic field, the torque or turning force is minimal in this position. The applied motor forces act left and right and are collinear *(1)*

(Torque explanations are acceptable.)

 It needs current reversal in this position so that a constant direction of turning force keeps the motor turning. *(1)*

**c.** *F = nBIL* = 150 × 0.06 × 0.5 × 0.065 *(1)*  = 0.293 = 0.29 N *(2)*

 (0.00195 N *(1)*, leaves out the turns)

**Question 14**

**a.** commutator C *(1)* slip rings B *(1)*

 Commutator reverses the voltage each half cycle making it all positive (or negative)

 Slip rings give direct access to the AC voltage generated as an alternator.

**b.** *ϕ = BA* = 0.06 × 0.07 × 0.065 *(1)* = 0.000273 = 2.7 × 10-4 Wb *(2)*

**c.** *f* = 25, *T* = 1/25 = 0.04, so ΔT = 0.010 s

*emf = n Δϕ /Δt*  (ignoring Lenz) = 150 × 2.73 × 10-4/ 0.04 / 0.25 *(1)*  = 4.095 = 4.1 V *(2)*

**d.**



must lose amplitude *(1)* and increase time period *(1)* polarity is unimportant, time can be longer

**Question 15**

**a.** When the switch closes or opens there is a **change** in the current flowing in the primary which generates a flux **change** which passes through the iron core of the secondary winding. *(1)*

The momentary flux change induces an opposing flux change and forces a current to flow in the secondary. Briefly the globe lights up. *(1)*

**b.** *N2 / N1 = V2 / V1* = 27 / 12 *(1)*  = 9 / 4 or 2.25 *(2)*

 0.44 (reciprocal of answer) *(1)*

**c.** The flux generated in the primary comes from each of the coils in the primary and adds up. *(1)*

This flux then passes through each coil of the secondary and generates a small voltage in each. These voltages from this large number of turns add up and give a larger voltage than the primary. *(1)*

(You are told that turn ratio (*N2 / N1 = V2 / V1)* increases the voltage, so this cannot be the answer on its own.)

**Question 16**

**a.** *I = P / V* = 3.0 × 107 / 2.75 × 105 =109 A *(1)*

 *R* = 1.2 × 106 × 1.05 × 10-4 = 126 so *Vdrop = IR* =109 × 126

= 1.37 × 104 V *(2)*

**b.** *Plost = I2R* = 1092 × 126 = 1.5 × 106 W *(1)*

 ratio = 1.5 / 30 = 0.05 or 5% lost so 95% delivered *(2)*

**c.** *Rtot* = 126 + 57 = 183

 *I = V / R* = 20000 / 183 = 109.3 A *(1)*

 *Pdelivered = I2R* = 109.32 × 57 = 680000 W = 680 kW *(2)*

**Question 17**

**a.** B *(1)*

**b.** direction of flow is best explained by Lenz’s Law *(1)*. (Faraday explains voltage not direction or polarity.)

flux through the coil increases downwards, so induced flux change is upwards.

inducing current in the coil must be anti-clockwise initially, reverses leaving the coil.

 re-entering the coil on the swing to the right is identical  *(1)*

**Question 18**

**a.** B You would expect 2 lighted areas and the rest of the screen in darkness.

 This is just a shadow formation process. *(1)*

**b.** *E = hc/λ* , *λ* = 4.14 × 10-15 × 3 × 108 / 1.97 *(1)* = 6.3 × 10-7 m = 630 nm *(2)*

 (answer must be in nm)

There is an exam instruction which says answers must be in the units specified in the answer.

**c.** *E* (Joules) = 1.97 × 1.6 × 10-19 = 3.15 × 10-19 J

 so photons = 1/ 3.15 × 10-19  *(1)* = 3.2 × 1018 *(2)*

**d.** PD to 630 nm 3rd node = 2.5 × 630 = 1575 nm *(1)*

 PD to other colour 3rd anti-node = 3 *λ* = 1575.

*λ* = 525 nm *(2)*

**Question 19**

**a.** The observation with different lights shows that the more energetic light can free the electrons but the weaker cannot. *(1)*

 If incandescent light could free the electrons, energy would have built up, each wave delivering some of the necessary energy. In a particle model, the energy of a photon is directly given to one electron. *(1)*

 (The inability of either light to discharge a positive electroscope supports the idea that the positive electroscope is already deficient in electrons. Positive charges are not involved in current flow in metals.)

**b.** graph drawn reasonably plotted, no negative energies *(1)*

*h* = (4.1 – 0.2) / (18 – 9) × 10-14 *(1)* = 4.3 × 10-15 eVs *(1)*

 realistic results are above 4.2 up to 4.4 × 10-15

 (4.14 × 10-15, no marks without a reasonable calculation)

**c.** extrapolate from the graph, *W* = 3.6 *(2)*

 *or* using some data *Ek = hf –W*, perhaps like this

 1.6 = 4.3 × 10-15 × 1.2 × 1015 – *W*

 1.6 = 5.16 – *W* so, *W* = 3.6 eV *(2)*



**d.** *Ekmax* = 4.3 × 10-15 × 1.4 × 1015 – 3.6 *(1)* = 2.42 = 2.4 eV *(2)*

**Question 20**

**a.** *v = √ (2E/m) = √* (2 × 18 × 1.6 × 10-19 / 9.1 × 10-31) *(1)*= 2.52 × 106

= 2.5 × 106 ms-1 *(2)*

**b.** *λ = h/mv* = 6.63 × 10-34 / 9.1 × 10-31 / 2.52 × 106 *(1)* = 2.9 × 10-10 m *(2)*

**c.** *E = hc/λ* = 4.14 × 10-15 × 3 × 108 / 2.9 × 10-10 *(1)* = 4.3 × 103 eV *(2)*

**Question 21**

**a.** *E =hc/λ*, 4.14 × 10-15 × 3 × 108 / 1.41 × 10-7 = 8.8 eV, *(1)* so energised at level n= 4,

 (or 8.8 eV level) *(2)*



**b.** The electrons exist as whole waves

within any level *(1)*

These waves can only exist as complete

entities as whole waves, fractional

 waves will not join up. *(1)*

or

These four sine waves in a circle join

because they are each whole waves. *(1)*

If there were not a whole number of waves a complete waveform could not exist. This is a wave property of matter.*(1)*

**c.** *E* = 4.14 × 10-15 × 5.1 × 1014 = 2.1 eV *(1)* (closest possible result) level 4 to 3. *(2)*

**Detailed Study 1: Einstein’s Relativity**

**Question 1 B**

Light speed is invariant for all observers, sound speed depends on the medium and its movement.

(Both experience Doppler change increasing frequency, which is not in the question.)

**Detailed Study 1: Einstein’s Relativity**

**Question 2 C**

*γ = 1/√*(1 – 0.82) = 1.667

*L = Lo √(1 – v2/c2) = Lo / γ* = 25 / 1.667 = 15 m

**Question 3 B**

They expected to see a change in the speed of light in different directions as the Earth moved through the ether wind.

**Question 4 D**

This is a definition of an inertial frame of reference.

**Question 5 B**

Calculation γ = 1/√ (1 – 0.62) = 1/0.8 so the *Ltrain = Lo train* × 0.8 = 400 m.

M sees both platform and train as the same length, so the flashes are simultaneous for M.

N sees the platform contracted to 320 m. As the 500 m train enters the forward light will trigger “long” before the rear one. N is also moving forward into this light flash. N will see the front light first.

**Question** **6 C**

In the muon frame of reference a length in the direction of motion only is contracted.

The vertical height will then be

*L = Lo / γ*  where γ *=* 1/√ (1 – 0.852) = 1.898

*L* = 5.5 × 10-11 / 1.898 = 2.9 × 10-11 m

**Question 7 A**

In the observer’s view, time is dilated so

*t* = 2.2 μs × γ = 2.2 × 10-6 × √(1 – 0.852) =2.2 × 10-6 × 1.90 = 4.2 μs

*d* = 0.85c × 4.2 × 10-6 = 1060 m

**Question** **8 C**

*Etotal = moc2γ* = 1.9x10-28 × (3 × 108)2 / √(1 – 0.852) = 3.2 × 10-11 J

added energy = *Etotal – moc2* = 3.2 × 10-11 – 1.9 × 10-28 × (3 × 108)2

= 1.5x10-11 J

*or*

*Ek = Eadded = moc2 (γ – 1)* = 1.9x10-28 × (3 × 108)2 × {1 / √(1 – 0.852) – 1}

= 1.5 × 10-11 J

**Question 9 D**

The energy constraint is even stronger than the mass issue (mass is part of the energy system *E = mc2*). There is no infinite source of energy to give the muon such a speed.

**Question 10 A**

This is the basic explanation of time dilation.

**Question** **11 D**

*γ = 1/√(1- β2)* where *β = v/c*

*β = √(1 – 1/γ2)*

*β1* = √(1 – 1/1.12) = 0.4166

*β2* = 2 × 0.4166 = 0.8331

*γ2* = 1/√(1 – 0.83312) = 1.81

**End of answers to the detailed study 1:**

**Detailed Study 2: Materials and their use in structures**

**Question 1 D**

X stretching is tensile, Y sideways forces are shear, Z squeezing is compressive.

**Question** **2 A**

The stiffest will have the steepest gradient under elastic conditions.

This is K. So *Y = Δ*σ /*Δ*ϵ = 3.0 × 108 / 1.5 × 10-3 = 2 × 1011 = 2.0 × 105 MPa

**Question 3 B**

Sample M

at ε = 5 × 10-3, σ = 5.0 × 108, *F = A*σ = π (0.012/2)2 × 5 × 108 = 5.65 × 104 N

**Question 4 B**

Sample L

toughness = area under stress-strain graph

= 0.5 × 3 × 10-3 × 4.0 × 108 + 2 × 10-3 × 4.0 × 108= 1.4 × 106 Jm-3

Evaluate the toughness, as measured by the total area under the stress-strain graph, of a material tested to the point of failure.

**Question 5 C**

accept L, this meets the requirements

reject J, little inelastic region, only moderate elastic limit

reject K, elastic region is short, elastic limit not very good

reject M, no plastic region, it is very brittle

**Question** **6 D**

arches and domes are used because the masonry materials are strong in compression and weak in tension. The load is entirely compressive in these designs. Answer C is quite incomplete.

**Question** **7 C**

The answer describes the structure, the road way is not uniformly compressed, only the top.

All the vertical stays and the suspension (curved) stays are in tension.

**Question** **8 A**

*τ = Fr* = 2000 × 10 × (20 + 30) + (30 + 25) / 2 × 22000 × 10 = 7.05 × 106  Nm

**Question 9 D**

*Fy = τ / r* = 7.05 × 106 / 30 = 235000 N

*Ftotal = W = mg* = (22000 + 2000) × 10 = 240000 N

*Fx* = 240000 – 235000 = 5 × 103 N (down)

**Question** **10 A**

*W* = 92 × 10 = 920 N

*Fline* = 920 / cos 26° / 14 = 73.1 N

*Area = π D2 /4* = 3.14 × 0.00352 / 4 = 9.62 × 10-6 m2

*σ = F/A* = 73.1 / 9.62 × 10-6 = 7.6 × 106 Pa

**Question** **11 B**

The graph shows the brittle character and the poorer compressive behaviour.

**End of answers to the detailed study 2:**

**Materials and their use in structures**

**Detailed Study 3: Further Electronics**

**Question 1 D**

*Vpp = VRMS 2 √2* = 36 V, so Vrms = 36 / 2 / √2 = 12.7 V

**Question 2 A**

*ratio = N1 / N2* = 120 / 12.7 = 9.43

The other answers are consequentially correct for the answers in Question 1

A → D, B → C, C→ B

**Question 3 C**

*Vp = VRMS√2* = 12 × √2 = 17 V, but 0.7 V is lost across each diode in a cycle, so

*Vp* = 17 – 1.4 = 15.6 V

**Question 4 D**

Vp is 15.6 but meters read VRMS. Under these conditions there will be no

difference between analogue and digital. Vmeter = 15.6 / √2 = 11.0 V

**Question 5 A**

The time constant is *τ = RC* = 1000 × 100 ×10-6 = 0.10 s, so it cannot drop as much as in D.

A is closer to showing what will happen in the 0.01 s of a single cycle in this power supply.

C shows no filter effect and B suggests a perfect regulation of the output.

**Question 6 D**

If a diode is open circuit, the second cycle of the AC voltage will not charge the capacitor. This cycle is seen to be missing.

**Question 7 B**

The time constant needs to increase and this change would be a substantial improvement.

The heat sink would only stop the diodes overheating, if this was a problem.

Steps C and D will both decrease the quality of the filtered output.

**Question 8 A**

This is the most accurate statement. The others contain irrelevancies and errors.

For answer C, R1 controls current not voltage. The zener sets the voltage.

**Question 9 C**

*I = P / V* = 0.4/12 = 0.033 = 33 mA

**Question 10 B**

the supply to 500 Ω requires 12 / 500 = 0.024 A and zero current through the zener,

under no load conditions this current can flow through the zener safely.

*R1 = (Vsupply – Vzener) / Imax* = (15 – 12) / 0.024 = 125 Ω

**Question 11 C**

Time constant is at 63% of final voltage while charging.

This is 0.63 × 12 = 7.56 V and occurs at 0.20 s

**End of answers to the detailed study 3:**

**Detailed Study 4: Synchrotron and its applications**

**Question 1 A**

The other statements are incorrect. The brightness of the synchrotron light is the only difference identified in these answers.

Laser light can be collimated and polarized, unlike x-rays

Synchrotron x-rays have wavelengths which interact with smaller atoms than conventional x-rays.

Lasers can operate down to infra-red wavelengths.

**Question 2 C**

The other statements are incorrect.

The storage ring does supply energy to maintain its level and applies acceleration to curve the path.

The beamline is linked to the storage ring.

The booster ring accelerates the electrons from an energy of 100 to 3000 MeV.

**Question 3 B**

The other statements are incorrect.

White light does not have a single wavelength and cannot be coherent

Magnets do accelerate electrons, but they don’t attract them. “D” is a very poor statement on the synchrotron.

**Question 4 D**

Monochromators work by transmitting selected wavelengths of light and other wavelengths are absorbed.

**Question 5 A**

angle = *sin-1(nλ/2/d)* = sin-1(1 × 0.15 / 2 / 0.28 ) = 15.5 °

**Question 6 C**

*d = n λ/ 2 / sin(A)* = 1 × 0.2 / 2 / sin(10.9) = 0.529 = 0.53 nm

 (using the other peaks as data gives 0.527 and 0.528 nm)

**Question 7 C**

These three properties make the synchrotron a good choice for research in a range of areas.

**Question 8 B**

*B = p/q/R* = 1.4 × 10-18 / 1.6 × 10 -19 / 36 = 0.24 T

**Question 9 C**

*F = qV/d* = 1.6 × 10-19 × 8 × 104 / 0.15 = 8.53 × 10-14 N

**Question 10 B**

*E photon after collision* = E initial – E electron = 200 – 65 = 135 keV

*λ = hc/E* = 4.14 × 10-15 × 3 × 108 / 135000 = 9.2 × 10-12 m

**Detailed Study 4: Synchrotron and its applications**

**Question 11 A**

All other statements are wrong. Thomson scattering is elastic so wavelength will not change.

If energy was to change so would momentum.

**Detailed Study 5: Photonics**

**Question 1 B**

All other statements are incorrect. Photons are produced in the release of energy as electrons move from the conduction to the valence band.

**Detailed Study 5: Photonics**

**Question 2** C

Each fibre carries a pixel of the image. Coherence in this case refers to the organisation of the bundle and not the light passing through it, which is commonly white.

**Design Study Reference:**

Explain fibre optic imaging in terms of coherent and incoherent bundles and in terms of composing images using many fibres, and that these fibres represent the pixels that form the image

**Web Links:**

VCAA exam 2013 Photonics Question 9

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2013/2013physics-cpr-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2013/physics_examrep13.pdf>

**Detailed Study 5: Photonics**

**Question 3 D**

Laser light is produced when a photon is used to trigger an energised population of atoms to release coherent photons of the same energy.

**Study Design Reference:**

Describe the production of light by coherent light sources (lasers), in terms of light amplification via stimulation from external photons.

**Web links:**

<http://www.rp-photonics.com/stimulated_emission.html>

<http://hyperphysics.phy-astr.gsu.edu/hbase/optmod/qualig.html>

**Detailed Study 5: Photonics**

**Question 4 D**

*Ac = sin-1(no/ni) = sin-1*(1.38/1.42) = 76.4°

**Study Design Reference:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.

**Web Link:**

<http://bit.ly/15BL11y>

<http://physicsnet.co.uk/a-level-physics-as-a2/waves/refraction/>

**Detailed Study 5: Photonics**

**Question 5 A**

*A2* = 90 – 76.4 = 13.6°,

*A1 = sin-1 (sin (90- Ac) × ni /next)*

*A1 = sin-1 (sin (A2 × ni /next)*

 *A1 = sin-1* (*sin* (13.6 × 1.42/1.33) = 14.6 °

**Study Design Reference:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.

**Web Link:**

<http://bit.ly/1bUPG4E>

<http://www.ciscopress.com/articles/article.asp?p=170740&seqNum=3>

**Detailed Study 5: Photonics**

**Question 6 D**

Incandescent light is always broad spectrum, and tends to be white. It is incoherent and the not in phase.

Laser light is a single wavelength (colour) and is coherent, in phase.

**Study Design References:**

Describe the production of incoherent light from wide spectrum light sources, including the Sun, light bulbs, and candles, in terms of the random thermal motion of valence electrons when atoms collide.

Describe laser light in terms of coherence, wavelength and phase.

**Web Links**:

<https://au.answers.yahoo.com/question/index?qid=20100408142622AAKZbCc>

<http://www.ehow.com/facts_5716808_regular-lights-vs_-laser-lights.html>

**Detailed Study 5: Photonics**

**Question 7 B**

This is Rayleigh scattering, which has less effect at longer wavelengths, up to a limit.

The peaks are caused by impurities in the cable material.

**Study Design Reference:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.

**Web Links:**

VCAA exam 2 Photonics, Question 9, 2012

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2012/2012physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2012/physics_assessrep_12.pdf>

<http://en.wikipedia.org/wiki/Rayleigh_scattering>

**Detailed Study 5: Photonics**

**Question 8 C**

1500 nm. This is the lowest point, least attenuation.

*E = hc/λ* = 4.14 × 10-15 × 3 × 108 / 1500 × 10-9 = 0.83 eV

**Study Design References:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.

Analyse the effect of band gap energy on LED colour, *Eg = hf = hc/λ.*

**Web Links:**

VCAA exam 2 Photonics, Question 9 and 10, 2010

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2010physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/physics2_assessrep_10.pdf>

[http://www2.cose.isu.edu/~hackmart/planck's.PDF](http://www2.cose.isu.edu/~hackmart/planck%27s.PDF)

**Detailed Study 5: Photonics**

**Question 9 C**

Material dispersion: a particular path has uniform material but its index of refraction varies for different wavelengths. Even if the path is the same, the speed will vary for different wavelength light.

Modal dispersion: light following slightly different TIR paths will take a different time to reach the other end. The speed will be the same.

**Study Design Reference:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.

**Web Links:**

VCAA exam 2 Photonics, Questions 11 and 12, 2009

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2009physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/physics_assessrep_nov09.pdf>

**Detailed Study 5: Photonics**

**Question 10 B**

This is macrobending, when the bend becomes so sharp, that TIR is lost between the core and the cladding.

**Study Design References:**

Analyse the operation of fibre optic wave-guides in terms of:

– light gathering ability using Snell’s Law, critical angle, total internal reflection and acceptance angle.

– attenuation by Rayleigh scattering.

– attenuation due to absorption by impurities in the fibre as well as the molecules that make up the fibre.

– physical characteristics of single mode and multimode optical fibres (step and graded index).

– causes of and methods to minimise material dispersion and modal dispersion.]

Describe the operation of optical fibres as simple, intensity-based sensors.

**Web Links:**

VCAA Photonics, Questions 11, 2013

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2013/2013physics-cpr-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2013/physics_examrep13.pdf>

VCAA exam 2 Photonics, Questions 7 and 8, 2009

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2009physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/physics_assessrep_nov09.pdf>

**Detailed Study 5: Photonics**

**Question 11 A**

The others all lose bandwidth or cost more than is necessary.

B laser diode for home is unnecessary

C short distance would do better with multi-mode

D LED and single mode over long distance will fail

**Study Design Reference:**

Compare optical fibres that are used for short and long distance telecommunications.

**Web Links:**

VCAA exam 2 Photonics, Question 11, 2010

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2010physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/physics2_assessrep_10.pdf>

VCAA paper 2 Photonics, Question 12,, 2011

<http://bit.ly/16gyqQs>

<http://bit.ly/14PswmH>

VCAA exam 2 Photonics, Questions 10 and 12, 2012

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2012/2012physics2-w.pdf>

<http://www.vcaa.vic.edu.au/Documents/exams/physics/2012/physics_assessrep_12.pdf>

**End of answers to the detailed study 5:**

**Photonics**

**Detailed Study 6: Sound**

**Question 1 C**

The dust is falling, but the vertical longitudinal waves move it up and down as it falls.

**Study Design Reference:**

Describe sound as the transmission of energy via longitudinal pressure waves.

**Web Link:**

<http://bit.ly/146P5ar>

**Detailed Study 6: Sound**

**Question 2 A**

*I = Io 10 (L/10)* = 1 × 10-12 × 10 (54/10) = 2.5 × 10 -7 Wm-2

**Study Design Reference:**

Analyse the differences between sound intensity (W m–2) and sound intensity level (dB).

**Web Link:**

<http://yhoo.it/12NusBV>

**Detailed Study 6: Sound**

**Question 3 B**

*r = r1 √(I1/Io)* = 2 × √ (2.5 × 10-7 / 1 x10-12) = 1000 m

or

threshold of hearing is also 0 dB.

Drop 6 dB for every doubling of distance

This is 9 doublings, distance = 1024, nearest answer is 1000.

**Study Design References:**

Calculate sound intensity at different distances from a source using an inverse square law, excluding acoustic power.

**Web Link:**

<http://bit.ly/18Y437j>

**Detailed Study 6: Sound**

**Question 4 D**

third harmonic will have 1.5 wavelengths in the string length

1.5 *λ* = 0.96, *λ* = 0.64

nodal separation = *λ / 2* = 0.32 m

**Study Design Reference:**

Analyse, for strings and open and closed resonant tubes, the fundamental as the first harmonic, and subsequent harmonics

**Web Links:**

<http://bit.ly/19D4PpC>

<http://bit.ly/13JJgvd>

**Detailed Study 6: Sound**

**Question 5 A**

Destructive interference forms the nodes, the anti-nodes are constructive. These are both processes of superposition.

**Study Design Reference:**

Explain resonance in terms of the superposition of a travelling wave and its reflection.

**Web Links:**

<http://hyperphysics.phy-astr.gsu.edu/hbase/sound/reflec.html>

<http://bit.ly/10ymFQF>

<http://bit.ly/hVFZFz> (This unsigned Java applet also needs you to approve it for security)

**Detailed Study 6: Sound**

**Question 6 C**

tube has pressure node at the open end,

distance to the node = 0.32, so full wavelength = 0.64

 (waves = 1.12 / 0.64 = 1.75 in the tube)

*f = v/*λ = 343/0.64 = 536 Hz

**Study Design References:**

Explain resonance in terms of the superposition of a travelling wave and its reflection.

Analyse, for strings and open and closed resonant tubes, the fundamental as the first harmonic, and subsequent harmonics.

Analyse sound using wavelength, frequency and speed of propagation of sound waves,

*v = f*λ*.*

**Web Link:**

<http://bit.ly/13ulfwR>

**Detailed Study 6: Sound**

**Question 7 B**

The other statements are incorrect for a closed tube.

The answer would be reversed for displacement nodes which are not on the course.

**Study Design References:**

Explain resonance in terms of the superposition of a travelling wave and its reflection.

Analyse, for strings and open and closed resonant tubes, the fundamental as the first harmonic, and subsequent harmonics.

**Web Links**

<http://hyperphysics.phy-astr.gsu.edu/hbase/waves/standw.html>

**Detailed Study 6: Sound**

**Question 8 D**

Electromagnetic induction produces a voltage, a sound to electrical transducer. Electromagnetic forces are produced by current, an electrical to sound transducer.

**Study Design References:**

Describe in terms of electrical and electromagnetic effects, the operation of

– microphones, including electret-condenser, crystal, dynamic and velocity microphones.

– dynamic loudspeakers.

**Web Link:**

<http://bit.ly/U8P1BI>

<http://hyperphysics.phy-astr.gsu.edu/hbase/audio/spk.html>

**Detailed Study 6: Sound**

**Question 9 C**

Only 500 Hz at 20 dB is on the 10 phon line



**Study Design Reference:**

Interpret frequency response curves of microphones, speakers, simple sound systems and hearing, including loudness (phon).

**Web Link:**

<http://bit.ly/15n3rpc>

**Detailed Study 6: Sound**

**Question 10 B**

D would only help the smallest of boats, which were blocked from the foghorn by wave crests. The others are wrong.

**Study Design Reference:**

Describe diffraction as the directional spread of various frequencies in terms of different gap width or obstacle size, including the significance of the magnitude of the *λ/w* ratio.

**Web Link:**

[http://en.wikipedia.org/wiki/Siren\_(alarm)](http://en.wikipedia.org/wiki/Siren_%28alarm%29)

<http://goldengatebridge.org/research/factsGGBFogHorn.php>

<http://bit.ly/15n4fuf>

**Detailed Study 6: Sound**

**Question 11 D**

Diffraction through a gap.

The speaker will lose upper frequency response because of the size of the speaker opening.

This will become apparent a frequencies above *f = v / λ* = 340 / 0.17 = 2000 Hz.

These waves will tend to become more directional and so will miss point T.

Higher frequencies will lose their diffractive spreading.

Diffraction and destructive interference.

The speaker will lose low frequency response when the wavelength is greater than the width of the baffle because these waves will reflect off the wall and destructively interfere with the forward waves from the speaker. This will become obvious when *f* = 340 / 0.4 = 850 Hz or less.

Lower frequencies will diffract around the baffle.

**Study Design References:**

Evaluate the fidelity of microphones and loudspeakers in terms of:

– the intended purpose of the device.

– the frequency response of the system.

– physical construction (qualitative).

Describe the effects of baffles and enclosures for loudspeakers in terms of the interference of sound waves due to phase difference.

**Web Links:**

gap

<http://www.schoolphysics.co.uk/age16-19/Wave%20properties/Diffraction/text/Diffraction_by_a_loudspeaker/index.html>]

destructive interference

<http://hyperphysics.phy-astr.gsu.edu/hbase/audio/spk2.html>

**End of answers to the detailed study 6:**

**Sound**

##### **End of answers for the 2014 Kilbaha VCE Physics Trial Examination**

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