2017
VCE
Physics
Trial Examination

Suggested Answers

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MULTIPLE CHOICE ANSWER SUMMARY

1	C	11	A
2	D	12	D
3	C	13	B
4	D	14	D
5	D	15	D
6	A	16	B
7	B	17	B
8	C	18	B
9	D	19	C
10	B	20	B

Distribution: A 2 B 7 C 4 D 7

Section A – Multiple choice

Question 1 Answer C
Field lines must flow from positive to negative charge

Study Design
- investigate and compare theoretically and practically gravitational fields and electrical fields about a point mass or charge (positive or negative) with reference to:
  —the direction of the field
  —the shape of the field

Web Link
http://www.physicsclassroom.com/class/estatics/Lesson-4/Electric-Field-Lines

Question 2 Answer D
Magnet X produces a field to the left, Magnet Y produces a field up the page.
Vector sum must be left and up, so in the range given by Answer D.
(The difference in the two fields only changes the angle within this range.)

Study Design
- describe the interaction of two fields, allowing that electric charges, magnetic poles and current carrying conductors can either attract or repel, whereas masses only attract each other

Web Link
http://www.emfs.info/what/adding/

Question 3 Answer C
using $F = \frac{kq_1q_2}{r^2}$
$F_{Q1T} = 9\times10^{9} \times 45\times10^{-6} \times 1.0\times10^{-6} / (0.15)^2 = +18$ N (left on charge T)
$F_{Q2T} = 9\times10^{9} \times 5.0\times10^{-6} \times 1.0\times10^{-6} / (0.05)^2 = -18$ N (right on charge T
sum is zero.

Study Design
- analyse the use of an electric field to accelerate a charge, including:
  —electric field and electric force concepts: $E = \frac{kq}{r^2}$ and $F = \frac{kq_1q_2}{r^2}$
- describe the interaction of two fields, allowing that electric charges, magnetic poles and current carrying conductors can either attract or repel, whereas masses only attract each other

Web Links
https://www.youtube.com/watch?v=0PNatMmKKUs
https://www.youtube.com/watch?v=S1TXN1M9t18

Question 4 Answer D

Using $g = G\frac{M}{r^2}$

$R_E = 6.37\times10^6$ m, extra height gives $R_2 = 6.37\times10^6 + 10000 = 6.38\times10^6$

$g = 9.81 \times (6.37\times10^6 / 6.38\times10^6)^2 = 9.78$ m s^{-2}

Study Design

• analyse the use of gravitational fields to accelerate mass, including:

—gravitational field and gravitational force concepts: $g = G\frac{M}{r^2}$ and $F = G\frac{M_1M_2}{r^2}$

—the use of the inverse square law to determine the magnitude of the field

Web Links

https://en.wikipedia.org/wiki/Gravity_of_Earth

http://www.physicsclassroom.com/class/circles/Lesson-3/The-Value-of-g

Question 5 Answer D

The height was chosen and this allowed the researchers to determine the gravitational field strength at two heights at that one location.

Study Design

• independent, dependent and controlled variables

Web Link

http://practicalphysics.org/variables.html

Question 6 Answer A

B Temperature
This would be much less, outside at 10000 m but would not be expected to affect gravity, especially inside the aircraft.

C The aircraft cabin used for the measurements at sea level
The distribution of mass locally could have an effect at very precise measurements.
It makes an immeasurable difference in this experiment.

D The strength of the gravitational field
This is not constant but varies, it is being measured.

A Location. It is expected that the variation with height at that location can be detected.

Study Design

• independent, dependent and controlled variables

Web Link

https://www.mansfieldct.org/Schools/MMS/staff/hand/Variables.htm

Question 7 Answer B

There is no start or end to magnetic field lines, because there are no magnetic monopoles to act as the beginning or end of the field lines.

Study Design

- investigate and compare theoretically and practically gravitational, magnetic and electric fields, including directions and shapes of fields, attractive and repulsive fields, and the existence of dipoles and monopoles

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/curloo.html
(first diagram)
http://www.physbot.co.uk/magnetic-fields-and-induction.html

Question 8 Answer C

The ranges which are implied for the data are then

A	8.27 to 8.37	8.32 to 8.42	considerable overlap, not different data
B	8.29 to 8.35	8.34 to 8.40	small overall
C	8.30 to 8.34	8.35 to 8.39	no overlap. separate data
D	8.31 to 8.33	8.36 to 8.38	no overlap, separate data

Best is Answer C with the largest allowable error.

Study Design

- methods of organising, analysing and evaluating primary data to identify patterns and relationships including sources of uncertainty and error, and limitations of data and methodologies
- the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation, including experiments (gravity, magnetism, electricity, Newton's laws of motion, waves) and/or the construction and evaluation of a device; precision, accuracy, reliability and validity of data; and the identification of, and distinction between, uncertainty and error

Web Link

http://ibguides.com/physics/notes/measurement-and-uncertainties

Question 9 Answer D

When the particle passes through the slit, the sideways location is quite precise. By implication then, the sideways momentum will have an enlarged error, seen in the fringe pattern.

Study Design

- explain how diffraction from a single slit experiment can be used to illustrate Heisenberg's uncertainty principle

Web Links

https://www.youtube.com/watch?v=a8FTr2qMutA
http://galileo.phys.virginia.edu/classes/252/uncertainty_principle.html

Question 10 Answer B

In principle, find the area under the graph between 330 and 430 km above the surface. The graph is effectively linear. Square counting and other methods can be used.

$W = m(g_1 + g_2)(h_1 - h_2) / 2$

$= 4.2\times10^5 \times (8.6 + 8.9)\ 1.0\times10^5 / 2 = 3.68\times10^{11}$ J

Study Design

• analyse the use of gravitational fields to accelerate mass, including:

—the change in gravitational potential energy from area under a force-distance graph and area under a field-distance graph multiplied by mass.

Web Links

https://www.khanacademy.org/science/physics/work-and-energy/work-and-energy-tutorial/v/work-as-area-under-curve

(starts at about 4.00)

http://hyperphysics.phy-astr.gsu.edu/hbase/wint.html

Question 11 Answer A

The width is not moving sideways with significant speed. Its proper value can be observed.

The length is moving with relativistic speed in that direction, so it is a relativistic length. Having measured the speed, then the proper length could be calculated, but would not be observed.

Study Design

• describe proper time *(t_0)* as the time interval between two events in a reference frame where the two events occur at the same point in space

• describe proper length *(L_0)* as the length that is measured in the frame of reference in which objects are at rest

Web Link

https://www.youtube.com/watch?v=a8FTr2qMutA

Question 12 Answer D

Surface water waves can be transverse because gravity can restore the flat water surface.

There is no sideways restoring force in water so the water waves below the surface are longitudinal.

Study Design

• explain a wave as the transmission of energy through a medium without the net transfer of matter

• distinguish between transverse and longitudinal waves

Web Link

https://www.quora.com/How-sound-waves-moves-in-water

Question 13 Answer B

$\boldsymbol{r} = \frac{mv}{qB} = 9.1\times10^{-31} \times 1.34\times10^{7} / 1.6\times10^{-19} / 0.055 = 1.4\times10^{-3}$ m

Study Design

• analyse the use of a magnetic field to change the path of a charged particle, including:

—the radius of the path followed by a low-velocity electron in a magnetic field: $\boldsymbol{r} = \frac{mv}{qB}$

Web Link

http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/movchg.html

Question 14 Answer D

The significant step here is that the wave is reflected, inverted.

This describes the detailed form of the superimposed waveform which forms in the string.

Study Design

- analyse the formation of standing waves in strings fixed at one or both ends
- explain resonance as the superposition of a travelling wave and its reflection, and with reference to a forced oscillation matching the natural frequency of vibration

Web Link

http://www.walter-fendt.de/html5/phen/standingwavereflection_en.htm

Question 15 Answer D

Noting the dot point below, the speed to light is invariant for all observers.

Study Design

- describe Einstein's two postulates for his theory of special relativity that:
  - —the laws of physics are the same in all inertial (non-accelerated) frames of reference
  - —the speed of light has a constant value for all observers regardless of their motion or the motion of the source
- compare Einstein's theory of special relativity with the principles of classical physics

Web Links

https://www.youtube.com/watch?v=WdfnRWGgbd0

https://physics.stackexchange.com/questions/160759/einsteins-first-postulate-implies-the-second

Question 16 Answer B

An electron bound to an atom can only release energy if a level transition occurs.

Study Design

- describe light as an electromagnetic wave which is produced by the acceleration of charges, which in turn produces changing electric fields and associated changing magnetic fields
- compare the production of light in lasers, synchrotrons, LEDs and incandescent lights.
- analyse the absorption of photons by atoms, with reference to:
  - —the change in energy levels of the atom due to electrons changing state

Question 17 Answer B

The path has no effect.

The greatest energy change will be indicated by the nearest final position to the central charge.

Study Design

- describe gravitation, magnetism and electricity using a field model
  - —potential energy changes (qualitative) associated with a point mass or charge moving in the field

Web Link

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elewor.html

Question 18 Answer B

Using Oersted's rule with curled fingers, the field in Coil A is to the left.
It will impose an increasing flux through Coil B to the left.
Coil B will induce an opposing flux against the imposed change. This change will increase in value, but will always be directed right.
An increasing current must flow from Y.

Study Design

- investigate and analyse theoretically and practically the generation of electromotive force (emf) including AC voltage and calculations using induced EMF: $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$, with reference to:
  —rate of change of magnetic flux
  —number of loops through which the flux passes
  —direction of induced emf in a coil
- investigate and apply theoretically and practically a vector field model to magnetic phenomena, including shapes and directions of fields produced by bar magnets, and by current-carrying wires, loops and solenoids

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html
http://www.tutorvista.com/content/physics/physics-iv/moving-charges-magnetism/moving-charges-magnetism.php

Question 19 Answer C

The actual gravitational force is unchanged in water although it is now supported by the spring balance and the water. $F_g = 0.270 \times 9.8 = 2.65$ N.
$F_{\text{on block by Earth}} = -F_{\text{on Earth by block}}$

Study Design

- investigate and apply theoretically and practically Newton's three laws of motion in situations where two or more coplanar forces act along a straight line and in two dimensions

Web Links

http://www.physicsclassroom.com/class/newtlaws/Lesson-4/Newton-s-Third-Law
http://www.animations.physics.unsw.edu.au/jw/Newton.htm

Question 20 Answer B

The $V_{\text{Peak to Peak}}$ is from trough to crest and this is 5 divisions, 10.0 V
V_{Peak} is half this value, from the centre zero line to the crest, 5.0 V
$V_{RMS} = V_P/\sqrt{2} = 3.54 = 3.5$ V

Study Design

- convert between rms, peak and peak-to-peak values of voltage and current

Web Link

http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/alternating-current-ac/

SECTION B
Question 1
a

$V_y = V \cos\theta$,
$= 28 \cos 15° = 3.88 \text{ ms}^{-1}$ *(1)*
$h_{vy=0} = V_y^2 / 2 / g = 0.77 \text{ m}$ *(2)*

b

$t_{fall} = \sqrt{(2h / g)}$
$= \sqrt{(2(35+0.78) / 9.8)} = 2.70 \text{ s}$ *(1)*
$t_{rise} = \sqrt{(2(0.77) / 9.8)} = 0.40 \text{ s}$
$t_{total} = 2.70 + 0.40 = 3.10 = 3.1 \text{ s}$ *(1)*

c

$V_x = 28 \cos 15° = 27.05$ *(1)*
$x_{range} = V_x \, t_{total} = (2.70 + 0.40) \times 27.05 = 83.78 = 84 \text{ m}$ *(1)*

Study Design
- investigate and analyse theoretically and practically the motion of projectiles near Earth's surface, including a qualitative description of the effects of air resistance

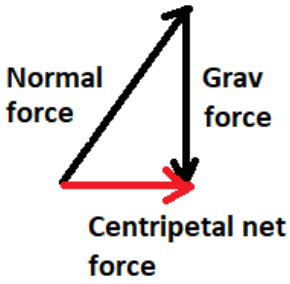
Web Links
http://formulas.tutorvista.com/physics/projectile-motion-formula.html
https://www.youtube.com/watch?v=ZnWP5h69DBM

Question 2
a a gravitational force down, vector tail on the centre of the coin *(1)* normal force, up through the coin *(1)*

b **C** *(1)*

c net force is centred, this is the direction of acceleration *(1)*

d $F_g = m \, 9.8$
$F_c = m \, 9.8 \tan 30° = m \, 5.66$ *(1)*
$m V^2 / R = m \, 5.66$
$V = \sqrt{(5.66 \times 0.31)} = 1.32 = 1.3 \text{ m s}^{-1}$ *(2)*



Study Design
- investigate and analyse theoretically and practically the uniform circular motion of an object moving in a horizontal plane: $F_{net} = m v^2 / r$, including:
  —a vehicle moving around a circular road
  —a vehicle moving around a banked track
  —an object on the end of a string

Web Links
http://www.physicsclassroom.com/class/vectors/Lesson-3/Addition-of-Forces
http://www.sparknotes.com/testprep/books/sat2/physics/chapter4section3.rhtml
http://hyperphysics.phy-astr.gsu.edu/hbase/cf.html

Question 3

a $\gamma = \frac{1}{\sqrt{(1-\frac{v^2}{c^2})}}$ = 1 / (1 – 0.98^2) = 5.02 = 5.0 *(1)*

b h = 2.2×10^{-6} × 0.98 c × 5 *(1)* = 3230 = 3.2×10^{3} m *(1)*

c The muon observer would see the length contracted, but would not see time dilation. This is the reverse of the Earth observer. *(1)*
The height travelled would be 2.2×10^{-6} × 0.98 c = 647 = 650 m *(1)*

d In either case in an average lifetime, a muon covers much of the journey to the Earth's surface. A small number will have a longer than average lifetime and will complete a journey 3 times as long as average. *(1)*
The relativistic journey is much easier to complete where a muon would on average travel only 650 m of the 1.0×10^{4} m in non-relativistic terms. *(1)*

e $E_K = (\gamma - 1)mc^2$ = (5 – 1) × 1.88×10^{-28} × $(3.0\times10^{8})^2$ = 6.8×10^{-11} J

Study Design

- describe proper time *(t_0)* as the time interval between two events in a reference frame where the two events occur at the same point in space
- describe proper length *(L_0)* as the length that is measured in the frame of reference in which objects are at rest
- model mathematically time dilation and length contraction at speeds approaching *c* using the equations: $t = t_o\,\gamma$ and $L = \frac{L_o}{\gamma}$ where $\gamma = \frac{1}{\sqrt{(1-\frac{v^2}{c^2})}}$
- explain why muons can reach Earth even though their half-lives would suggest that they should decay in the outer atmosphere.
- interpret Einstein's prediction by showing that the total 'mass-energy' of an object is given by: $E_{total} = E_k + E_o + \gamma mc^2$ where $E_o = mc^2$ and where kinetic energy can be calculated by: $E_K = (\gamma - 1)mc^2$

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/Relativ/muon.html
(note that lifetime is measured in half-life, not half survival time)
http://hyperphysics.phy-astr.gsu.edu/hbase/Relativ/releng.html

Question 4

a $n_1 \, sin\theta_1 = n_2 \, sin\theta_2$
$n_2 = n_1 \sin \theta_1 / \sin \theta_2$
$= 1.33 \times \sin 44° / \sin 31°$ *(1)*
$= 1.79$ *(2)*

b angle will decrease because index of refraction increases for lower wavelengths

c $\theta_{crit} = \sin^{-1} (n_2 / n_1)$
$= \sin^{-1} (1.79 / 1.33)$ *(1)*
$= 48°$ *(2)*

d $n_1 \, v_1 = n_2 \, v_2$
$v_2 = c / n_2$
$= 3\times10^8 / 1.79 = 1.67\times10^8$ m s^{-1} *(1)*

Study Design

- investigate and analyse theoretically and practically the behaviour of waves including:
  - refraction using Snell's Law: $n_1 \, sin\theta_1 = n_2 \, sin\theta_2$ and $n_1 \, v_1 = n_2 \, v_2$
  - total internal reflection and critical angle including applications:
- investigate and explain theoretically and practically colour dispersion in prisms and lenses with reference to refraction of the components of white light as they pass from one medium to another

Web Links

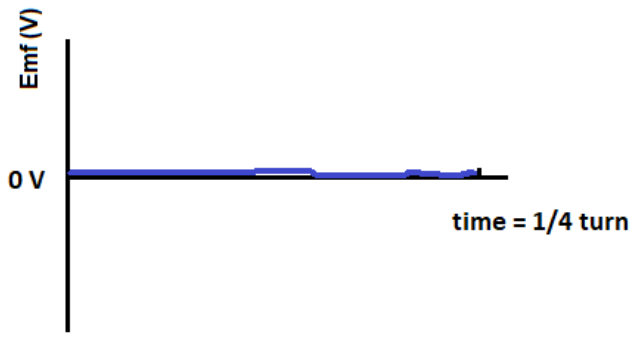
http://scienceprimer.com/snells-law-refraction-calculator
http://www.physicsclassroom.com/class/refrn/Lesson-3/The-Critical-Angle

Question 5

a $\Delta\Phi = BA = 0.35 \times 0.040^2 = 5.6\times10^{-4}$ *(1)*
$\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = 50 \times 5.6\times10^{-4} / 0.015 = 1.87 = 1.9$ V *(2)*

b The upwards flux will reduce, so an induced upward flux will be produced. *(1)*
Using Oersted's grip rule this current must flow F to E *(1)*

c



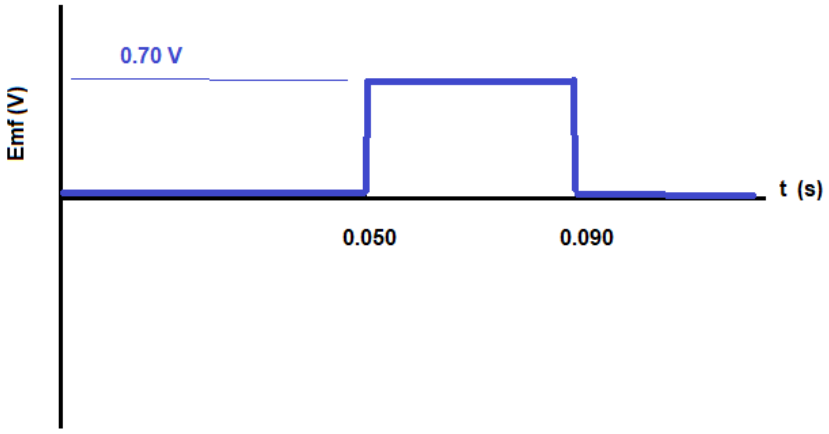
(1) for showing zero voltage
(No flux change)

Question 5 (continued)

d $\Delta\Phi = BA = 0.35 \times 0.040^2 = 5.6\times10^{-4}$

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = 50 \times 5.6\times10^{-4} / 0.040 = 0.70$ V *(1) could be conseq from **5a***

negative version of the graph is also correct



e Using design "a" rotate on an axis aligned with the leads. *(1)*
Output to be taken from the leads with a split commutator to ensure constant polarity. *(1)*
(designs based on "d" cannot provide a continuous supply.)

Study Design

- investigate and analyse theoretically and practically the generation of electromotive force (emf) including AC voltage and calculations using induced EMF: $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$, with reference to:
  - —rate of change of magnetic flux
  - —number of loops through which the flux passes
  - —direction of induced emf in a coil
- explain the production of DC voltage in DC generators and AC voltage in alternators, including the use of split ring commutators and slip rings respectively.
- calculate magnetic flux when the magnetic field is perpendicular to the area, and describe the qualitative effect of differing angles between the area and the field: $\Phi = BA$

Web Link

http://www.wright.edu/~guy.vandegrift/openstaxphysics/chaps/23%20Electromagnetic%20induction%20AC%20currents.pdf
(Useful up to p 9 of the pdf)

Question 6

a *B* is down, current is out of page in WZ, so *F* is right. *(1)*

b $F = nBIL = 100 \times 0.075 \times 0.24 \times 0.062$ N *(1)* = 0.112 = 0.11 N *(2),*
(no turns value 1)

c 0.11 N, *F* = unchanged *(1)*

d the vertical position is best because the force is perpendicular to the rotation length this will give the motor a starting torque (twist) *(1)*
In "c" the force only tries to stretch the coil. *(1)*

e When the coil has turned 90° the commutator will reverse the current flow in the coil, reversing the flow will reverse the direction of the force *(1)*
the side which had been forced left (WZ) passes the switching point at the horizontal position and will be forced into a constant rotation *(1)*
The switching is at the horizontal position where the torque has dropped to zero. *(1)*

Study Design

- investigate and analyse theoretically and practically the force on a current carrying conductor due to an external magnetic field, $F = nIlB$ where the directions of *I* and *B* are either perpendicular or parallel to each other
- investigate and analyse theoretically and practically the operation of simple DC motors consisting of one coil, containing a number of loops of wire, which is free to rotate about an axis in a uniform magnetic field and including the use of a split ring commutator

Web Links

http://spiff.rit.edu/classes/phys213/lectures/magwire/magwire_long.html
http://web.mit.edu/cmse/educational/Beauvais_DC_Motor_LP.pdf

Question 7

a PD = $n\lambda$ = 2 × 6.20×10^{-7} = 1.24×10^{-6} m *(1)*

b PD = $(n - \frac{1}{2})\lambda$ = 2.5 × 6.20×10^{-7} = 1.55×10^{-6} m *(1)*

c Bright bands are constructive superposition, crests and crests or troughs and troughs meet, with separation $n\lambda$ *(1)*
Dark bands are destructive superposition, crests and crests and troughs meet, with separation $\left(n - \frac{1}{2}\right)\lambda$ *(1)*

d Using $\Delta x = \frac{\lambda L}{D}$ and $c = f\,\lambda$
$\Delta x_{water}/\Delta x_{air} = \lambda_{water}/\lambda_{air} = v_{water}/c$ *(1)* or similar process
v_{water} = c × 5.6 / 7.4 = 2.27×10^{8} = 2.3×10^{8} m s^{-1} *(1)*

Study Design

• explain the results of Young's double slit experiment with reference to:
—evidence for the wave-like nature of light
—constructive and destructive interference of coherent waves in terms of path differences: $n\lambda$ and $\left(n - \frac{1}{2}\right)\lambda$ respectively
—effect of wavelength, distance of screen and slit separation on interference patterns: $\Delta x = \frac{\lambda L}{D}$
• investigate and analyse theoretically and practically constructive and destructive interference from two sources with reference to coherent waves and path difference: $n\lambda$ and $\left(n - \frac{1}{2}\right)\lambda$ respectively

Web Links

http://tap.iop.org/vibration/superposition/page_39888.html
https://www.kullabs.com/classes/subjects/units/lessons/notes/note-detail/1725
http://www.physicsclassroom.com/class/light/Lesson-3/Young-s-Equation
https://www.kullabs.com/classes/subjects/units/lessons/notes/note-detail/1725

Question 8

a With more wave impacts, more energy will be delivered to the electrons *(1)* and some electrons will be freed even at lower frequencies than before. *(1)*

b No matter how much energy is delivered in total it is quantised and the electrons can only accept a single quanta of energy, *(1)* so no electrons will be freed because the quanta are too small. *(1)*

c gradient = h = (1.55 – 0) / (10 – 6.4)×10^{15} = 4.3×10^{-15} eV s *(1)*

Planck's constant determines the energy of a photon, E = hf *(1)*

d using $E_{K\,max} = hf - W$
use any convenient point of data and h from Answer c
0 = 4.3×10^{-15} × 6.4×10^{14} = 2.74 = 2.7 eV *(1)*
Accept answers 2.7 – 2.8, *conseq. from Answer c*
Max *(1) for h assumed to be 4.14×10^{-15} eV s*

Study Design

- analyse the photoelectric effect with reference to:
  - —evidence for the particle-like nature of light
  - —experimental data in the form of graphs of photocurrent versus electrode potential, and of kinetic energy of electrons versus frequency
  - —kinetic energy of emitted photoelectrons: $E_{k\,max} = hf - \phi$, using energy units of joule and electron-volt
  - —effects of intensity of incident irradiation on the emission of photoelectrons
- describe the limitation of the wave model of light in explaining experimental results related to the photoelectric effect.

Web Links

https://atarnotes.com/forum/index.php?topic=18105.0
https://www.miniphysics.com/failure-of-classical-wave-theory.html
https://www.reddit.com/r/askscience/comments/2hda4d/how_does_the_photoelectric_effect_prove_the_wave/

Question 9

a if globe C has 4.81 V and R_G = 5.00 Ω then I_3 = 4.81 / 5 = 0.962
V_{R2drop} = 0.4 × 0.962 = 0.3848 *(1)*
V_B = 4.81 + 0.3848 = 5.19 (accept 5.20) V *(2)*

b $P_{RL2} = IR^2 = 0.962^2 \times 0.4 = 0.370$ W
$P_{G3} = 0.962^2 \times 5 = 4.627$ W *(1)*
ratio = 0.37 / (0.37 + 4.627) = 0.074 *(2) or 7.4%*

c If the voltage is raised, at constant power, then current drops, *(1)*
and the power loss in the lines will be reduced. *(1)*
In this case, use heavier wires which will have less resistance. This will reduce $P_{loss} = I^2R$. *(1)*
(Accept an argument which uses correcting step-up transformers at globes B and C to get the potential back to 6.00 V).

Study Design

• analyse transformer action with reference to electromagnetic induction for an ideal transformer:
$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
• analyse the supply of power by considering transmission losses across transmission lines
• identify the advantage of the use of AC power as a domestic power supply.
• compare alternating voltage expressed as the root-mean-square (rms) to a constant DC voltage developing the same power in a resistive component
• identification and application of relevant health and safety guidelines

Web Links

http://www.bbc.co.uk/bitesize/standard/physics/energy_matters/source_to_consumer/revision/4/
http://practicalphysics.org/ac-power-line-high-voltage.html
http://vcephysics.com/content/wp-content/uploads/2012/01/Power-Transmission.pdf

Question 10

a $p_{initial} = 0.024 \times 1.34 + 0.010 \times 0 = 0.03216$ N s *(1)*
$p_{final} = 0.03216$, $p_{2'} = (0.03216 - 0.024 \times 0.74) / 0.010 = 1.44$ m s^{-1} *(2)*

b $p_{sideways} = 0 = 0.024 \times 0.025 + 0.010 \times v_{2\ sideways}$ *(1)*
$v_{2\ sideways} = -0.060$ m s^{-1} right or 0.060 m s^{-1} left *(2)*

c Energy is converted to heat in distortion during the collision, (some as sound which will also become heat.) *(1)*

Study Design

• investigate and apply theoretically and practically the laws of energy and momentum conservation in isolated systems in one dimension.
• analyse transformations of energy between kinetic energy, strain potential energy, gravitational potential energy and energy dissipated to the environment (considered as a combination of heat, sound and deformation of material):
—kinetic energy at low speeds: $E_K = \frac{1}{2}mv^2$; elastic and inelastic collisions with reference to conservation of kinetic energy
• investigate and analyse theoretically and practically impulse in an isolated system for collisions between objects moving in a straight line: $F\Delta t = m\Delta v$

Web Links

http://www.animations.physics.unsw.edu.au/jw/momentum3.html
http://www.physicsclassroom.com/calcpad/momentum
http://spiff.rit.edu/classes/phys311.old/lectures/elas/elas.html
http://www.dummies.com/education/science/physics/how-to-determine-whether-a-collision-is-elastic-or-inelastic/
http://www.kcvs.ca/map/java/applets/collisions_1D/applethelp/lesson/lesson_2.html

Question 11

a $E = hc/\lambda$
so $\lambda = 4.14\times10^{-15} \times 3\times10^{8} / 15600$ *(1)* $= 7.96\times10^{-11}$ m *(2)*

b In 1 s the energy = 0.020 J
$E_{photon} = 15600 \times 1.6\times10^{-19} = 2.496\times10^{-15}$ J *(1)*
$n = 0.020 / 2.496\times10^{-15} = 8.01\times10^{12} = 8.0\times10^{12}$ photons *(2)*

c $E = hc/\lambda \quad \Delta x = \frac{\lambda L}{D}$
If energy decreases, then λ increases *(1)*
If λ increases, then pattern spreads *(1)*

d 7.96×10^{-11} *(1)*
Wavelength must be the same, metres *(1)*
accept equal momentum, more work but equally correct

Study Design

- interpret electron diffraction patterns as evidence for the wave-like nature of matter
- distinguish between the diffraction patterns produced by photons and electrons
- calculate the de Broglie wavelength of matter: $p = \frac{h}{\lambda}$.
- compare the momentum of photons and of matter of the same wavelength including calculations using: $p = \frac{h}{\lambda}$.
- describe the quantised states of the atom with reference to electrons forming standing waves, and explain this as evidence for the dual nature of matter

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/debrog.html
https://ecee.colorado.edu/~bart/book/ex009.htm
https://www.chemteam.info/Electrons/LightEquations2-Wavelength-Freq-Energy-Problems11-20.html

Question 12

a 12.1 to 12.8**,** so 0.7 eV

b arrow points up from 12.1 to 12.8 eV (n = 3 to n = 4)

c 12.1 to 10.2 eV so emits 1.9 eV (n = 3 to n = 2)

d electrons bound in atoms form standing waves around the atom; for a standing wave to be stable it will be structured with a number of complete waves. *(1)*
These complete waves establish the energy levels; their differences are the quantisation of the energy identified in emission and absorption spectra. *(1)*

Study Design

- explain the production of atomic absorption and emission line spectra, including those from metal vapour lamps
- describe the quantised states of the atom with reference to electrons forming standing waves, and explain this as evidence for the dual nature of matter

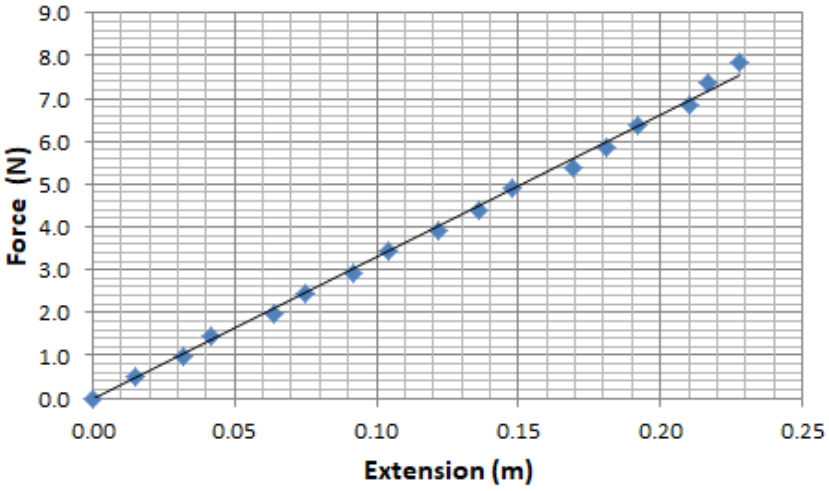
Web Links

http://www.wiley.com/legacy/Australia/PageProofs/Phy2_VCE_U3&4_c12_web.pdf
pages 7 and 27 of pdf
http://www.chemguide.co.uk/atoms/properties/hspectrum.html

Question 13

a F_g = m g where g = gravitational field strength (9.8 N kg^{-1}) *(1)*

b *(1) well centred line*
(1) starts at origin



c line of best fit starts at the origin so select a convenient second point for gradient
k = 6.60 / 0.200 = 33.0 N kg^{-1} *(1)*

d $E_S = \frac{1}{2}k\Delta x^2$ = 0.5 × 33 × 0.136^2 *(1)* = 0.305 = 0.31 J *(2)*

e 0.31 J *(1)* *conseq*

f F_g = 0.450 × 9.8 = 4.41 N down
F_s at 0.176 = 5.8 N up *(1)*
F_{net} = 5.8 – 4.4 = 1.4
a = 1.4 / 0.45 = 3.1 m s^{-2} *(2) (-1) if more or less significant figures*

g a = 0, forces are balanced at this point *(1)*

Study Design

- analyse transformations of energy between kinetic energy, strain potential energy, gravitational potential energy and energy dissipated to the environment (considered as a combination of heat, sound and deformation of material):
  - —strain potential energy: area under force-distance graph including ideal springs obeying Hooke's Law: $E_S = \frac{1}{2}k\Delta x^2$
- investigate and apply theoretically and practically the concept of work done by a constant force using:
  - —work done = constant force × distance moved in direction of net force
  - —work done = area under force-distance graph
  - —potential energy changes in a uniform gravitational field: $mg\Delta h$

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/gpot.html
(ignore calculus)
http://www.wiley.com/legacy/Australia/PageProofs/c04Gravitation_web.pdf
pdf pp 12 -14

Question 14

a p = 2, *(1)* q = 4 *(1)*

b $m = E/c^2 = 7.65\times10^{26} / (3\times10^8)^2$ *(1)* $= 8.5\times10^9$ kg *(2)*

Study Design

• describe how matter is converted to energy by nuclear fusion in the Sun, which leads to its mass decreasing and the emission of electromagnetic radiation.

Web Links

https://en.wikipedia.org/wiki/Proton%E2%80%93proton_chain_reaction
http://solar-center.stanford.edu/FAQ/Qshrink.html
https://science.slashdot.org/story/12/02/02/1844205/is-the-earth-gaining-or-losing-mass

Question 15

a speed of light is constant at 3×10^8 m s^{-1} *(1)*
light has two transverse components, an electric and a magnetic *(1)*

b If both filter are aligned a ray of light readily passes through both filters, but not if they are at right angles *(1)*
Light has many directions for its transverse wave direction when produced, but only that aligned with the filter passes through the first filter. This aligned polarised light is completed blocked by a filter at 90°. *(1)*

c radio AM and FM, TV, communications, microwaves (radar and cooking) infra-red (thermal imaging) etc. *(2 for any 2)*

d X-rays, medical, astronomy, materials research
γ rays, astronomy
synchrotron radiation, research especially materials
UV, images very hot objects
(2 for any 2 identified uses and waves)

Study Design

• identify that all electromagnetic waves travel at the same speed, ***c***, in a vacuum
• compare the wavelength and frequencies of different regions of the electromagnetic spectrum, including radio, microwave, infrared, visible, ultraviolet, x-ray and gamma, and identify the distinct uses each has in society
• explain polarisation of visible light and its relation to a transverse wave model

Web Links

https://www.quora.com/Is-it-possible-to-separate-electric-and-magnetic-field-components-of-light-How
https://en.wikipedia.org/wiki/Electromagnetic_radiation
https://www.boundless.com/physics/textbooks/boundless-physics-textbook/electromagnetic-waves-23/the-electromagnetic-spectrum-165/radio-waves-592-11171/
https://www.livescience.com/50399-radio-waves.html
https://en.wikipedia.org/wiki/X-ray
https://imagine.gsfc.nasa.gov/science/toolbox/observing_platforms1.html
http://www.physicsclassroom.com/class/light/Lesson-1/Polarization
http://www.edu.pe.ca/gray/class_pages/krcutcliffe/physics521/16light/articles/Polarization%20of%20Light.htm

Question 16

a $E_{silicon} = 0.7 = hf = hc / \lambda$
$\lambda = 0.68 \times 3\times10^{8} / 4.14\times10^{-15} = 1.83\times10^{-6} = 1.8\times10^{3}$ nm *(1)*
$E_{red} = 1.7 = hc / \lambda$
$\lambda = 2.20 \times 3\times10^{8} / 4.14\times10^{-15} = 5.65\times10^{-7} = 565 =$ nm *(1)*
The wavelength of the silicon diode is in the infra-red. It will look dark, while that of the green is visible. *(1)*

b electrons drop from the conduction band to the valence band when they reach the junction, releasing a specific quantum of energy. *(1)*

Study Design

• interpret spectra and calculate the energy of absorbed or emitted photons: $\Delta E = hf$
• compare the production of light in lasers, synchrotrons, LEDs and incandescent lights.

Web Links

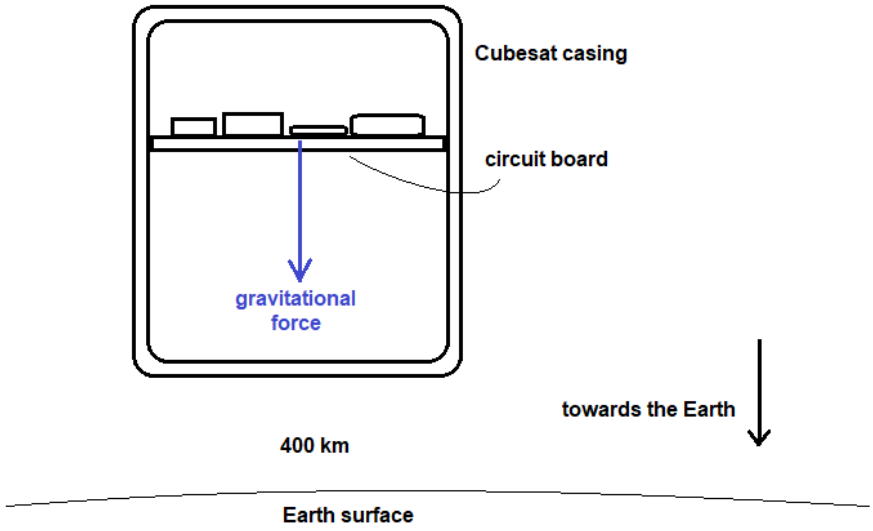
http://www.bbc.co.uk/education/guides/zppnn39/revision/3
http://faculty.sites.uci.edu/chem1l/files/2013/11/RDGLED.pdf

Question 17

a $a = v^2/R = 7650^2 / 6.8\times10^6 = 8.61 = 8.6 \text{ m s}^{-2}$ *(1)*

b The centripetal force is produced by the gravitational force and the acceleration needed is the same for the body of the satellite and the circuit board. *(1)*
There is no force between the satellite body and the circuit board, so no force or reaction force will be observed. *(1)*

c *(1)*



Study Design

- apply the concepts of force due to gravity, F_g, and normal reaction force, F_N, including satellites in orbit where the orbits are assumed to be uniform and circular

Web Links

http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/hump.html
http://wordpress.mrreid.org/2014/04/09/real-and-apparent-weightlessness/

End of answers for the 2017 Kilbaha VCE Physics Trial Examination

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