B

Free Exam
for 2013-16 VCE study design

Engage Education Foundation

Units 3 and 4 Physics

Practice Exam Solutions

Stop!

Don't look at these solutions until you have attempted the exam.

Any questions?

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Section A – Core

Marks allocated are indicated by a number in square brackets, for example, [1] indicates that the line is worth one mark.

Part 1: Motion in one and two dimensions

Question 1

Arrow drawn from center of ball towards center of circle [1]

Question 2

Correct use of formula [1]

$$F = \frac{mv^2}{r} = \frac{m4\pi^2 r}{T^2}$$

$$\therefore F = \frac{70 \times 10^{-3} \times 4 \times \pi^2 \times 40 \times 10^{-2}}{1.2^2}$$

$$\therefore F = 0.77\ N$$

Correct answer reached [1]

Question 3

- Explanation of the difference between speed (rate of change of distance travelled) and velocity (rate of change of displacement), or explanation that speed is a scalar quantity while velocity is a vector quantity [1]
- Although the ball is moving at constant speed, because its direction of motion is constantly changing, its velocity is changing [1]
- Since acceleration is the rate of change of velocity, this means that the ball has an acceleration, and thus the net force on the ball cannot equal zero [1]

Question 4

- Constant [1]
- Zero [1]
- Increasing [1]
- Constant [1]

Question 5

Horizontal component of the object's velocity is constant, at 3 m s^{-1}

The vertical component of the object's velocity:

$$u = 0; v = v; s = 24; a = g = 10; t = t$$

$$v^2 = u^2 + 2as$$

$$\therefore v^2 = 2 \times 10 \times 24$$

$\therefore v = 21.9\ m\ s^{-1}$ [1] (One mark for adequate application of the formulas)

Use vector addition to find the object's final velocity, $= \sqrt{3^2 + 21.9^2} = 22.1\ m\ s^{-1}$ [1]

Question 6
First find the time taken for the object to reach the ground, using the vertical components

$u = 0; v = 22.1; s = 24; a = g = 10; t = t$

$v = at + u$

$\therefore t = 2.2\ s$ [1]

This value for t can be used with the horizontal components to give the distance travelled horizontally

$u = 3;\ v = 3;\ a = 0;\ s = R;\ t = 2.2$

$s = ut + \frac{1}{2}at^2$

Therefore the distance travelled by the projectile is 6.6 m [1]

Question 7
Doubling the mass has no effect on the object's trajectory, if air resistance is ignored [1]

Question 8
- Correct general shape of line, fitting inside the curve of the original trajectory [1]
- Shorter range [1]

Question 9
Use of $F = ma$ to find force exerted on the spring by the hanging mass in its equilibrium position

$F = 50 \times 10^{-3} \times 10 = 0.5\ N$ [1]

Use of $F = -kx$ to find value of spring constant, where x=block's displacement from its equilibrium position

$0.5 = -k \times (-0.06)$

$\therefore k = 8.33$ N m^{-1} [1]

Question 10
- Use of $E = \frac{1}{2}kx^2$ formula to find spring potential energy when the block is at maximum displacement [1]
- $E = 0.5 \times 8.33 \times 0.04^2 = 6.67 \times 10^{-3}\ J$ [1]

Question 11
- Mention of conservation of energy- energy cannot be created or destroyed, but it can change from one form to another [1]
- When the block is at its maximum displacement from its equilibrium position (i.e. the spring is at 12 cm or 20 cm), all the energy of the system is potential energy in the spring [1]
- As the block moves towards its equilibrium position, this is converted to kinetic energy, and at the equilibrium position all the energy in the system is kinetic energy. (or words to that effect) [1]

Question 12
- No energy is lost, but in a real world situation some energy is converted to sound or thermal energy as the block and spring oscillate [1]

- Since some energy is lost to the surroundings, this results in a gradual decrease in the amplitude of these oscillations [1]

Question 13
Use of the equation for circular motion to find the net force on the satellite:

$$F = \frac{m4\pi^2 r}{T^2}$$

This gives the centripetal force on the satellite. T and r are known [1]

This can be equated to Newton's law of universal gravitation:

$$F = G\frac{Mm}{r^2}$$

Where M is the mass of the planet, m is the mass of the satellite, and r is known [2]

$$\therefore \frac{4\pi^2}{T^2} = \frac{GM}{r^3}$$

Solving this, the mass of the planet, M, is 2.84 x 10^{25} kg [2]

Question 14
Momentum [1]

Question 15
Kinetic energy $= \frac{1}{2}mv^2 = \frac{1}{2} \times 140 \times 10^{-3} \times 3.2^2 = 0.717\ J$ [1]

Question 16
First find the horizontal force by finding the horizontal acceleration:

$u = 3.2; v = 0; s = 2.8; a = a$

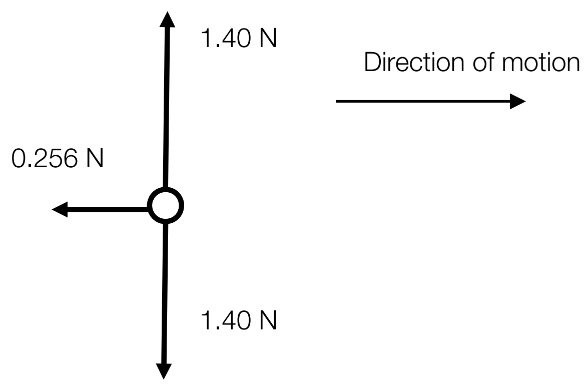
$v^2 = u^2 + 2as$

$\therefore a = -1.83\ m\ s^{-2}$ [1]

$F = ma = 0.140 \times -1.83 = -0.256\ N\ (or\ 0.256\ N\ in\ the\ direction\ opposing\ motion)$ [1]

Then find the vertical force components: $F = mg = 0.140 \times 10 = 1.40\ N$ [1]

Finally, draw forces in correct directions [1]



Part 2: Electronics and photonics

Question 1a

Resistance for section with components in parallel:

$$\frac{1}{R} = \frac{1}{14} + \frac{1}{16} + \frac{1}{12}$$

$\therefore R = 4.6\ \Omega$ for parallel section [1]

Therefore R_{total} for the circuit = $4.6 + 20 + 25 = 49.6\ \Omega$ [1]

Question 1b

Method 1:

Use of ratios to determine proportion of potential difference across each resistor:

20:25:4.6

=9.7:12.1:2.2, therefore 9.7 V is potential difference across R_1 [1]

Use of $V = IR$ to find total current in circuit as 0.484 A

Use of $P = VI$, gives power dissipated in R_1 as 4.7 W [1]

Method 2:

$R_{\text{total}} = 49.6\ \Omega$

Use of $V = IR$ to find total current in circuit as 0.484 A

Resistance of $R_1 = 20\ \Omega$

$P=I^2R$, $P=0.484^2 \times 20 = 4.7$ W [2] (1 mark for applying right formula)

Question 1c

From b), $V = I \times R_{total\ of\ parallel\ resistor} = 0.484 \times 4.6 = 2.23V$ [1]

Voltage across R2 is the same as the voltage across all the parallel resistors.

Question 2

- Ammeter connected in series [1]s
- Voltmeter connected in parallel [1]

Question 3

Resistors all connected in parallel, so:

$\frac{1}{R_{\text{total}}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{8}\ \therefore R_{\text{total}} = 2.18\ \Omega$ [1]

Use of V=IR to find total current through circuit = 5.5 A [1]

Use of ratios or individual V=IR equations to determine current is divided amongst components in parallel as 2, 2, and 1.5 A

Use of $P = VI$ to find power dissipated in light bulb

$P = VI = 12 \times 1.5 = 18\ W$ [1]

Question 4

- Increasing the resistance of the variable resistor will decrease the total current through the circuit, but will also decrease the proportion of this current that flows through the variable resistor (or vice versa if its resistance is decreased) [1]
- The light bulb is connected in parallel, so always receives 12 V, and has a fixed resistance of 8 Ω. Neither of these values changes, and so through V=IR, the current through the light bulb does not change [1]
- This means that changing the resistance of the variable resistor will have no effect on the power dissipated in the light bulb [1]

Question 5

$$Efficiency = \frac{Power\ out}{Power\ in} \times 100$$

$$\therefore 0.35 = \frac{0.08}{Power\ in}$$

Therefore the power in = 0.23 W [1]

P=VI, so current =15 mA [1]

Question 6

$Gain = \frac{Vout}{Vin} = \frac{5}{0.04} = 125$ [1]

Question 7a

At 10 lux, the resistance of the LDR = 10,000 Ω (read off graph)

Also at 10 lux, the light turns on, indicating that the potential difference across the LDR at this point equals 8.8 V [1]

$V = IR$, therefore current through the LDR at 10 lux equals 0.88 mA [1]

The LDR and R_1 are connected in series, so the same current flows through both of them

The potential difference across R_1 equals $(15 - 8.8) = 6.2\ V$ [1]

Use of $V = IR$ to find the resistance of R_1:

$6.2 = 0.88 \times 10^{-3} \times R$

$\therefore R = 7.0k\Omega$ [1]

Question 7b

- Increasing the resistance of R_1 will decrease the proportion of potential difference across the LDR [1]
- This means that for the required voltage drop for the switching circuit to turn the light on, Tom will have to wait until the resistance of the LDR increases, which will happen when the room is darker [1]

Question 7c

Tom should decrease the voltage supplied to the switching circuit. The overall drop in voltage means that at the intensity of 10 lux, the circuit will not switch on. Therefore the resistance of LDR must increase in order to reach the required circuit, this occurs when the room gets darker.

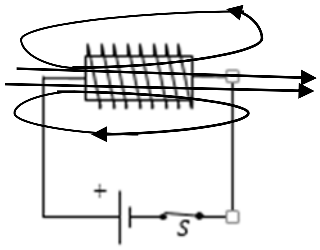
Question 8a
All resistors connected in parallel [1]

Question 8b
Any arrangement where the 2 Ω resistor is connected in parallel, and is receiving the full 12 volts available [1]

Part 3: Electric power

Question 1

- correct identification of north and south on bar, and thus correct direction of arrows on field lines [1]
- correct general shape of field lines - around 4 lines should be included [1]



Question 2

A positive current (according to the ammeter) is induced. [1]

Question 3

A negative current is induced. [1]

Question 4

By Lenz's law, the induced current must generate a magnetic field that partially opposes the change in magnetic flux. In question 2, there was an increase of flux from left to right, so the magnetic field generated by the induced current be orientated right to left. And vice versa. [3]

Question 5

Use $\frac{V_1}{V_2} = \frac{N_!}{N_2}$ to get input voltage for transmission line as 40,000 V [2]

Question 6

$I_2 = \frac{N_1 I_1}{N_2} = 10\ \mathrm{A_{RMS}}$. Then use of $P_{loss} = I^2 R$ to get resistance of transmission line as $75\ \Omega$. [1]

Then use of $V_{drop} = IR$ to give voltage drop = 750 V [1]

Question 7

$V_{available} = \frac{39250}{160} = 245.31\ \mathrm{V}$ [2]

Question 8

$\mathrm{Cable\ length} = \frac{75}{0.001} = 75\ \mathrm{km}$. Therefore, the generating station is $37.5\ \mathrm{km}$ from the substation. [2]

Question 9

Lines are parallel to field. Therefore, $0\ \mathrm{N}$. [2]

Question 10

AC can be transformed; DC cannot. In situations like this one, large amounts of power are being transmitted, but the wires used are not ideal, and so will have some resistance. This means that some power is lost. Power lost is proportional to the current in the wires squared. By reducing the current through the wires, less power is lost. This is why AC is preferential to DC; it is possible to transmit AC at a low current to minimize power losses, which isn't possible with DC. [3]

Question 11

Split-ring commutator. [1]

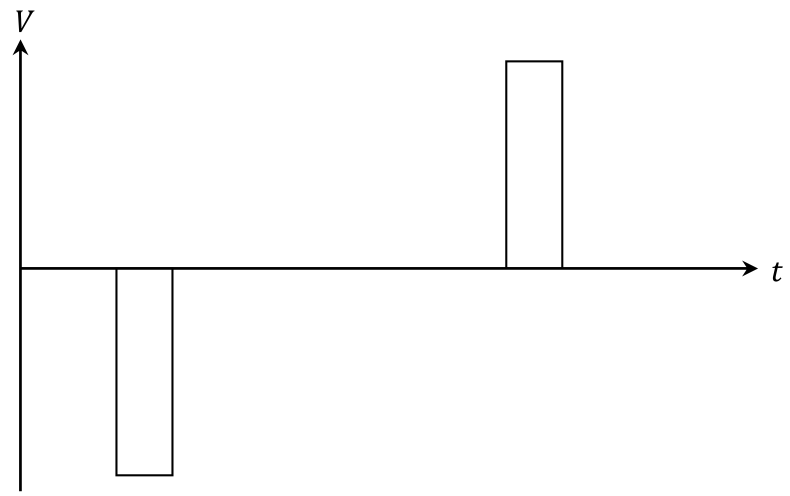
It reverses the current every half a turn, ensures that the voltage across T_1 and T_2 is always of the same sign. [2]

Question 12
$EMF = NBA\omega \sin(\omega t)$. So, $EMF_{max} = NBA\omega$. Now $\omega = 20 \times 2\pi = 40\pi$, so $EMF_{max} = 25 \times 0.7 \times 0.15^2 \times 40\pi \approx 49.48$ V [2]

Question 13
By Faraday's law, $EMF = -\frac{\Delta\phi}{\Delta t}$. The greatest change in flux occurs when the plane of the loop is parallel to the magnetic field. [2]

Question 14
The correct answer is C. [2]

Question 15



[2]

Question 16
By Lenz's law, the induced emf must partially oppose the change in flux. As the loop enters the field, there is an increase of flux through the loop, out of the page. Therefore, by the right hand rule, the induced current must be from B to A. Therefore, the voltage is negative. As the velocity is constant, the rate of change of flux is constant, so by Faraday's law, the voltage is constant as the loop enters and exits the field. [3]

Question 17
$EMF = -n\frac{\Delta\phi}{\Delta t} = -25\frac{4.6\times10^{-2}\times 25\times10^{-4}}{10^{-2}} = -0.2875$ V [2]

Question 18

$$EMF = -N\frac{\Delta\Phi}{\Delta t} = -N\frac{BA}{\Delta t}$$

$$\frac{EMF_1}{EMF_2} = \frac{N_1A_1}{N_2A_2} = \frac{25 \times 2.5 \times 10^{-3}}{10 \times 7.5 \times 10^{-3}} = 0.83$$

[1 for correct formula, 1 for correct answer]

Part 4: Interactions of light and matter

Question 1

Experiments demonstrating the photoelectric effect. Explanations could include observations that cannot be reconciled by the wave model, such as a threshold frequency, or that there is no noticeable delay between the arrival of incident light and the emission of electrons. [2]

Question 2

Answer could include Young's double slit experiment. Diffraction patterns and interference observed support the wave model. [2]

Question 3

Increasing the intensity of the incident light has no effect on the energy of the emitted electrons. (The *number* of electrons emitted depends on the intensity.) [2]

Question 4

Light from the sun is wide spectrum, laser light is monochromatic. Light from the sun is incoherent, laser light is coherent: all the photons are in phase with each other. [3]

Question 5

Diffraction pattern should be more spread out; central band must still be present [2]

Question 6

Bright fringes occur at when the path difference is an integer multiple of the wavelength; if the wavelength is increases, the path differences to each fringe will be larger; hence the pattern is more spread out. [2]

Question 7

- Use $E = hf$ and $c = f\lambda$. [1]
- Using the eV value for Planck's constant, this gives wavelength = 1.38 x 10^{-10} m [1]

Question 8

Use $\lambda_{de\ Broglie} = \frac{h}{p} \Rightarrow\ p = \frac{h}{1.38\times10^{-10}}\ E_k = \frac{p^2}{2m} = \frac{\left(\frac{6.64\times10^{-34}}{1.38\times10^{-10}}\right)^2}{9.11\times10^{-31}} = 15.88\ eV$ [2]

Question 9

Both matter and light have wave-like properties. Both x-rays and electrons have the same wavelength, and so diffract identically. [2]

Question 10

Converting the 5.11 eV from the work function to joules: $5.11\ \times\ 1.6\ \times\ 10^{-19} = 8.18\ \times\ 10^{-19}$ J

Energy of a photon: use $E = \frac{hc}{\lambda}$ to give energy = 8.29 x 10^{-19} J

The kinetic energy of the electron is 8.29 x $10^{-19} - 8.18\ \times\ 10^{-19}$ = 1.1 x 10^{-20}

Use $KE = \frac{1}{2}mv^2$, to give velocity of electron: 1.56 x 10^5 ms^{-1} [3]

Question 11

Atom is in its first excited state. If it were in any higher state, it would be capable of emitting a photon of more than one possible value of energy. [1]

Question 12

- arrows from 2nd excited state to 1st excited state and to ground state. [1]
- arrow from 1st excited state to ground state. [1]

Question 13

- Award marks for understanding that this is a hypothesis about the wave like properties of matter, such as particles like electrons and make references to the link between wavelength and energy of matter [1]
- Mention standing waves will only be formed when the circumference of the orbit is a whole number of wavelength. Diagram may be used to aid explanation, but are not required. [1]

Section B – Detailed Studies

Einstein's special relativity

Question 1

The correct answer is D. From Alice's perspective, light must travel an equal distance to reach the front and rear walls. As the speed of light is constant for all observers, the light pulse travels a shorter distance to reach the rear wall (which moves towards the pulse) than the front wall (which moves away from the pulse) in Bob's frame of reference.

Question 2

The correct answer is D. A and C are related to the result of the experiment, though not the purpose of it. B was an attempt to make the results of the Michelson-Morley experiment consistent with the existence of the ether.

Question 3

The correct answer is D. A and B are unrelated to the result of the experiment. C is true, though not immediate from the results of the experiment.

Question 4

The correct answer is A. Use $L = \frac{L_0}{\gamma}$

Question 5

The correct answer is C. Use $t = t_0\gamma$

Question 6

The correct answer is B. Total energy released is $5.49 + 5.49 + 12.86 = 23.84\ MeV$. $E = mc^2$ yields the desired result.

Question 7

The correct answer is A.

Question 8

The correct answer is C. The height of the tower is perpendicular to the swallow's direction of travel; it is not length contracted in the bird's frame of reference.

Question 9

The correct answer is C. Evaluate by comparing the change in kinetic energy in each case by using $E_k = (\gamma - 1)m_0c^2$.

Question 10

The correct answer is D. The ISS orbits the earth and the earth is rotating (and also orbiting the sun); circular motion requires acceleration, therefore the two are non-inertial frames. For the curious, look up the Foucault pendulum.

Question 11

The correct answer is A.

Use $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ to show that $v = \frac{2\sqrt{6}}{5}c = 2.997 \times 10^8 m/s$ (Alternatively, make the approximation $v \approx c$).

Hence, the proper decay time is $t_{decay} = \frac{87\times10^{-6}}{2.997\times10^8} = 2.90 \times 10^{-13}$. So the observed decay time is 25 times this.

Question 12

The correct answer is B. Use the fact that $E_k = \frac{\gamma - 1}{\gamma} \times E_{total}$, so $E_k = \frac{24}{25} \times 7.11 \times 10^{-9} = 6.83 \times 10^{-9} J$

Materials and their use in structures

Question 1
The correct answer is A.

Question 2
The correct answer is D.

Question 3
The correct answer is D.

Question 4
The correct answer is B.

Question 5
The correct answer is C.

Question 6
The correct answer is B.

Question 7
The correct answer is C.

Question 8
The correct answer is A.

Question 9
The correct answer is A.

Question 10
The correct answer is B.

Question 11
The correct answer is B.

Question 12
The correct answer is D.

Further electronics

Question 1
The correct answer is A.

Question 2
The correct answer is D.

Question 3
The correct answer is A.

Question 4
The correct answer is B.

Question 5
The correct answer is C.

Question 6
The correct answer is B.

Question 7
The correct answer is B.

Question 8
The correct answer is A.

Question 9
The correct answer is B.

Question 10
The correct answer is D.

Question 11
The correct answer is B. $\frac{8.75}{\sqrt{2}} - 1.4 \approx 5\ V$, 2 diodes plus converting peak to peak into root means square, will be a straight graph because τ is much greater than the period.

Question 12
The correct answer is A. Zener diodes in reverse restrict voltage to a specified number, in this case 2.5.

Synchrotron and its applications

Question 1
The correct answer is B.

Use that $F = qvB$ for an electron in a magnetic field, and that for circular motion $F = \frac{mv^2}{r}$

Question 2
The correct answer is C.

Use $F = qvB$.

Question 3
The correct answer is C.

Question 4
The correct answer is A.

Use $qV = KE = \frac{1}{2}mv^2$ for a particle with charge q passing through a potential V

Question 5
The correct answer is C.

Use $qV = KE$

Question 6
The correct answer is B.

Question 7
The correct answer is A.

B is true though not relevant. C and D are both false.

Question 8
The correct answer is D.

Use $E_{photon} = hf = \frac{hc}{\lambda}$.

Question 9
The correct answer is C.

Question 10
The correct answer is A.

Use $2d \sin\theta_n = n\,\lambda$. As we want the first peak, $n = 1$

Question 11
The correct answer is D.

Using Bragg's law, we find that $\sin\theta_3 = 1.15 > 1$, which is impossible. Hence, there is no third peak.

Question 12
The correct answer is C.

Inelastic scattering of light results in the production of longer wavelength light.

Photonics

Question 1
The correct answer is C.

Question 2
The correct answer is B.

Question 3
The correct answer is C.

Question 4
The correct answer is A.

Question 5
The correct answer is D.

Question 6
The correct answer is B.

Question 7
The correct answer is D.

Question 8
The correct answer is B.

Question 9
The correct answer is B.

Question 10
The correct answer is A.

Question 11
The correct answer is B.

Question 12
The correct answer is C.

Sound

Question 1
The correct answer is D.

Question 2
The correct answer is C.

Question 3
The correct answer is B.

Question 4
The correct answer is B.

Question 5
The correct answer is A.

Question 6
The correct answer is D.

Question 7
The correct answer is C.

Question 8
The correct answer is B.

Question 9
The correct answer is A.

Question 10
The correct answer is D.

Question 11
The correct answer is C.

Question 12
The correct answer is D.