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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

For net force, arrow drawn from centre of ball towards centre of circle and gravitational force arrow pointing down the page. [1]

Question 2

Correct use of formula [1]

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

$$\therefore F = \frac{100 \times 10^{-3} \times 4 \times \pi^2 \times 30 \times 10^{-2}}{1.2^2}$$

$$\therefore F = 0.82\ N$$

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]
- Constant [1]

Question 5

The vertical component of the object's velocity:

$v_y = 10 \times \sin(60°) = 8.66\ ms^{-1}$ [1]

$$0 = 8.66^2 + 2 \times (-10) \times d$$

$$d = 3.75m$$

Therefore, the maximum height reached is d + height of the experiment = 3.75 + 1.6 = 5.35 m [1]

Question 6

First using symmetry properties we know that on the way down when it is 1.6 m above the ground it will also be travelling at 10 m/s at an angle of 60° to the horizontal. Therefore, we can now calculate the final vertical velocity. [1]

v = final velocity; a = 10; d = 1.6; u = 8.66

$v^2 = 2ad + u^2$

$\therefore v = 10.3\ ms^{-1}$ [1]

With this value we add the horizontal velocity as well to get the final answer.

$v = \sqrt{{v_x}^2 + {v_y}^2} = \sqrt{5^2 + 10.3^2} = 11.4\ ms^{-1}$ [1]

Question 7

To find the value of the range you need to figure out the time for the total journey.

First we calculate the time it takes to rise and then fall back to the same height, t:

$v_y = 8.66; a = 10$

$v = u + at$

$0 = 8.66 - 10 \times t$

$t = 0.866$

Hence, $t_{\text{flight}} = 1.732\ s$ [1]

Then we calculate the time it takes to reach the ground:

$v = u + at$

$10.3 = 8.66 + 10 \times t$

$t = 0.164$ [1]

Therefore, $t_{\text{total}} = 0.164 + 1.732 = 1.9\ s$ and therefore, the range is $1.9 \times 5 = 9.48\ m$ [1]

Question 8

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

Question 9

Use $F = -kx$ to find the k value by finding the ratio of the force to extension:

$k = \frac{F}{x}$ [1]

$= \frac{14}{0.04}$

$\therefore k = 350$ [1]

Question 10
Use $E = \frac{1}{2}kx^2$ formula to find spring potential energy [1]

$E = 0.5 \times 350 \times 0.04^2 = 0.28\,J$ [1]

Question 11
Use potential energy = kinetic energy: $\frac{1}{2} \times k \times \Delta x^2 = \frac{1}{2} \times m \times v^2$ [1]

$v^2 = \frac{k \times \Delta x^2}{m}; v = 3.35\,ms^{-1}$ [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]
- Mention of conservation of energy- energy cannot be created or destroyed, but it can change from one form to another [1]

Question 13
Use 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]

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

Solving this, the period of the comet's orbit, T, is 4.63×10^5 seconds [2]

Question 14
Momentum [1]

Question 15
Using conservation of momentum the velocity of the planet can be found to be: v = 280 m/s [1]

Kinetic energy $= \frac{1}{2}mv^2 = \frac{1}{2} \times 3.7 \times 10^{22} \times 280^2 = 1.45 \times 10^{27}\,J$ [1]

Question 16
Kinetic energy beforehand:

$K_I = \frac{1}{2}m_{comet}{v_{comet}}^2 + \frac{1}{2}m_{planet}{v_{planet}}^2 = \frac{1}{2} \times 3.7 \times 10^{22} \times 1000^2 + \frac{1}{2} \times 3.7 \times 10^{22} \times (-720)^2 = 2.8 \times 10^{28}\,J$ [1]

$K_F = \frac{1}{2}m_{planet}{v_{planet}}^2 = \frac{1}{2} \times 3.7 \times 10^{22} \times (280)^2 = 1.45 \times 10^{27}\,J$ and thus, $K_I \neq K_F$ [2]

Therefore, energy is not conserved and energy has been converted to sound or heat. [1]

Part 2: Electronics and photonics

Question 1

Resistance for section with components in parallel:

$$\frac{1}{R} = \frac{1}{12} + \frac{1}{6}$$

$\therefore R = 4\ \Omega$ for parallel section [1]

Therefore R_{total} for the circuit = $4 + 6 = 10\ \Omega$ [1]

Question 2

Voltage across resistor formula:

$$V = \frac{R_{resistor}}{R_{total}} \times V_{total}$$

Total equivalence resistance of the circuit is:

$$R_{total} = 6 + \frac{1}{\frac{1}{12}+\frac{1}{6}} = 10 \text{ [1]}$$

$$\therefore V_1 = \frac{6}{10} \times 12 = 7.2\ V \text{ [1]}$$

Question 3

Power dissipated formula:

$$P = \frac{V^2}{R}$$

$$\therefore P = \frac{7.2^2}{6} = 8.64\ W \text{ [1]}$$

Question 4

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

Question 5

$Gain = \frac{Vout}{Vin} = \frac{20}{0.08} = 250$ [1]

Question 6a

2 kΩ (read off graph) [1]

Question 6b

At 25°C, the resistance of the thermistor = 1000 Ω (read off graph)

Also at 25°C, the air conditioner turns on, indicating that the potential difference across the thermistor at this point equals 16 V [1]

$V = IR$, therefore current through the thermistor at 25° equals 16 mA [1]

The thermistor and variable resistor are connected in series, so the same current flows through both of them

The potential difference across the variable resistor equals $(24 - 16) = 8\ V$ [1]

Use of $V = IR$ to find the resistance of the variable resistor:

$8 = 16 \times 10^{-3} \times R$

$\therefore R = 0.5\ k\Omega$ [1]

Question 6c

- At a lower temperature the resistance of the thermistor will be lower [1] and therefore the potential difference across it will be lower [1]
- Therefore the voltage across the variable resistor will increase [1]
- Hence, the resistance of the variable resistor would have to be greater [1] Question 7c

Question 7a

The total potential difference across the parallel part is 20 V, hence across the resistor there is 120 – 20 = 100 V [1]

Question 7b

Use of $V = IR$ to find the current through the variable resistor:

$100 = 8 \times I$

$\therefore I = 12.5\ A$ [1]

Question 7c

LED's 2 & 4 Remain on. [2]

Part 3: Electric power

Question 1

Field lines coming out of the right side of the solenoid [1]

Field lines going into the left side of the solenoid [1]

Question 2

$\Phi = B \times A$

$\therefore \Phi = 6.0 \times 10^{-2} \times \pi \times (0.15)^2 = 4.24 \times 10^{-3}\ Wb\ A$ [1]

Question 3

$emf = -\frac{\Delta\Phi}{\Delta t}$ [1]

$= -\frac{0 - 4.24 \times 10^{-3}}{5}$ [1]

= 0.85 mV [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 3, there was a decrease of flux from positive to zero, so the magnetic field generated by the induced current must have a negative magnitude. [3]

Question 5

Use $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ to get input voltage for transmission line as 32,000 V [2]

Question 6

$I_{In\ wire} = \frac{2000}{100} = 20$

$P_{loss} = I^2 \times R = 20^2 \times 50 = 2 \times 10^4\ W.$ [1]

Question 7

$V_{loss} = \frac{P_{loss}}{I} = \frac{2\times10^4}{20} = 1000\ V$ [1]

Question 8

$P_{available} = P_{Produced} - P_{loss} = 640000 - 20000 = 6.2 \times 10^4\ W$ [1]

$V_{available} = \frac{6.2 \times 10^4}{20} = 31000\ V$

$V_{at\ farm} = \frac{3100}{100} = 310\ V$

[1]

Question 9

Lines are parallel to field. Therefore, 0 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]

Ensures that the voltage across T_1 and T_2 is always of the same sign. [2]

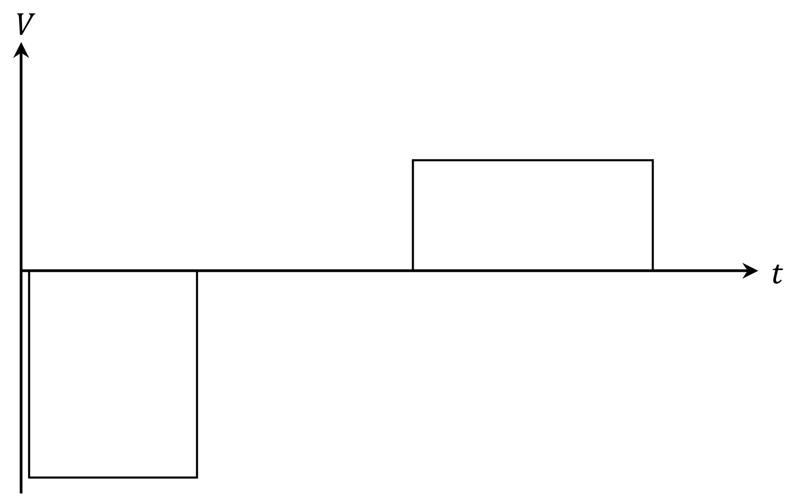
Question 12
$EMF = NBA\omega \sin(\omega t)$. So, $EMF_{max} = NBA\omega$. Now $\omega = 20 \times 2\pi = 40\pi$, so $EMF_{max} = 25 \times 0.7 \times 0.15^2 \times 40\pi \approx 49.48 \text{ V}$ [2]

Question 13
A slipring is a conductive ring - usually solid - on which a conductive brush/contact rides so as to complete a circuit even as the ring turns. It is frequently used on AC motors and generators. [1] A split ring is split into pieces so there is no electrical connection between the pieces. The contact that rides on a spit ring completes different circuits or the same circuit in different directions as the ring rotates – usually used for DC generators [2].

Question 14
The correct answer is D. [2]

Question 15
The correct answer is C. [2]

Question 16



[2]

Question 17
Faraday's Law states that an emf is produced when there is a change in flux with respect to time [1]. The initial change in flux is quite steep so the emf is quite large [1] whereas the decrease in flux produces more emf but of a lesser magnitude. [1]

Question 18

By Lenz's law, the induced emf must partially oppose the change in flux. As the magnetic field decreases the flux decreases inside the loop. Therefore, a current is produced to increase the current in the loop and by the right hand rule; the induced current must be from B to A. [2]

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
Doubling the intensity does not change the shape or the values of the graph. However it does double the amount of electrons at the maximum kinetic energy [2]

Question 6
By replacing the material with one with a lower work function the minimum frequency for electrons to be ejected is at a lower frequency. Thus the graph will have an x-intercept at a lower value. The gradient of the graph however will remain the same. Double the intensity doesn't necessary change anything as the actual change comes from the change in material. [3]

Question 7
Use $E = hf$ and $c = f\lambda$. [1]

Using the eV value for Planck's constant, this gives wavelength = 1.38×10^{-10} m [1]

Question 8
Both matter and light have wave-like properties. Both x-rays and electrons have the same wavelength, and so diffract identically. [2]

Question 9
Converting the 5.11eV 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 = 8.29×10^{-19} J

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

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

Question 10
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 11
Arrow from 2nd excited state to 1st excited state and to ground state. [1]

Question 12
Award marks for understanding that this is a hypothesis about the wave like properties of matter, such as particles like electrons [1]. The energies available to an electron can be explained using the different possible standing waves that could form- "electron in a box" model [1]. Diagram may be used to aid explanation, but are not required.

Section B – Detailed Studies

Each correct answer is worth 2 marks.

Einstein's special relativity

Question 1

The correct answer is A.

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{2.8 \times 10^8}{3 \times 10^8}\right)}}, l = \frac{l_o}{\gamma}$$

Question 2

The correct answer is C. Speed of light does not change so use $t = \frac{x}{s}$.

Question 3

The correct answer is C. Speed cannot reach the speed of light, so speed only increases slightly and most energy is stored as mass.

Question 4

The correct answer is D.

Question 5

The correct answer is B. Use $W = m_0\gamma c^2 - m_0c^2$.

Question 6

The correct answer is D.

Question 7

The correct answer is B. Special relativity resulted from the findings of the experiment. The experiment found the speed of light to be the same in all directions.

Question 8

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

Question 9

The correct answer is B. Total energy = kinetic energy + m_0c^2.

Question 10

The correct answer is A. The plane is accelerating hence not an inertial frame of reference.

Question 11

The correct answer is D. Use $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$.

Materials and their use in structures

Question 1
The correct answer is D.

Question 2
The correct answer is A.

Question 3
The correct answer is D.

Question 4
The correct answer is D.

Question 5
The correct answer is B.

Question 6
The correct answer is C.

Question 7
The correct answer is B.

Question 8
The correct answer is B.

Question 9
The correct answer is B.

Question 10
The correct answer is C.

Question 11
The correct answer is A.

Further electronics

Question 1
The correct answer is B.

Question 2
The correct answer is A.

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 A.

Question 7
The correct answer is B.

Question 8
The correct answer is C.

Question 9
The correct answer is B.

Question 10
The correct answer is D.

Question 11
The correct answer is D.

Synchrotron

Question 1
The correct answer is D. Anything that accelerates the electron *perpendicular* to its direction of travel will result in synchrotron radiation.

Question 2
The correct answer is C. A stronger magnetic field will result in sharper acceleration of electrons which will produce higher frequency photons – i.e. more energetic.

Question 3
The correct answer is B.

Question 4
The correct answer is C.

Question 5
The correct answer is C.

Question 6
The correct answer is B. Use $2d \sin\theta = n\lambda$

Question 7
The correct answer is A. Same as before.

Question 8
The correct answer is D. Remember, θ was varied from 0 to 180

Question 9
The correct answer is C.

Question 10
The correct answer is D.

Question 11
The correct answer is C. Since the field is directed out of the page and the motion is clockwise, we can use the right hand rule to show the charge is positive. Since the particle is in circular motion, $F = \frac{mv^2}{r}$. Since the only force is magnetism, $F = qvB$. Equating and solving for q gives the result. Incidentally, the particle is a positron.

Photonics

Question 1
The correct answer is C.

Question 2
The correct answer is A.

Question 3
The correct answer is B.

Question 4
The correct answer is D.

Question 5
The correct answer is D.

Question 6
The correct answer is D.

Question 7
The correct answer is B.

Question 8
The correct answer is A.

Question 9
The correct answer is C.

Question 10
The correct answer is C.

Question 11
The correct answer is B.

Sound

Question 1
The correct answer is C.

Question 2
The correct answer is B.

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 C.

Question 10
The correct answer is D.

Question 11
The correct answer is D.

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