PHYSICS

Units 3 & 4 – Written examination

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(*TSSM's* 2008 trial exam updated for the current study design)

SOLUTIONS

SECTION A - Multiple Choice (1 mark each)

Question 1

Answer: D

Explanation:
Magnetic, electric and gravitational field lines never cross.

Question 2

Answer: C

Explanation:
Using the right hand rule the force depends on the direction of the field and the direction of the current

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Question 3

Answer: A

Explanation:

$$Vq = \frac{1}{2}mv^2$$

$$V = \frac{9.1\times10^{-31}\times\left(0.06\times3\times10^{8}\right)^{2}}{2\times1.6\times10^{-19}}$$

$$V = 921V$$

Question 4

Answer: B

Explanation:

$$r = \frac{mv}{Bq}$$

$$B = \frac{mv}{rq}$$

$$B = \frac{9.1\times10^{-31}\times\left(0.01\times3\times10^{8}\right)}{2.1\times10^{-3}\times1.6\times10^{-19}}$$

$$B = 8.1\times10^{-3}\,T$$

Question 5

Answer: A

Explanation:

$F = qvB$

$F = 1.6 \times 10^{-19} \times \left(0.01 \times 3 \times 10^{8}\right) \times 8.125 \times 10^{-3}$

$F = 3.9 \times 10^{-15}\ N$

Question 6

Answer: A

Explanation:

$$R_E = \sqrt{\frac{6.67 \times 10^{-11} \times 81M}{9.8}}$$

$$R_M = \sqrt{\frac{6.67 \times 10^{-11} \times M}{1.6}}$$

$$\frac{R_E}{R_M} = \frac{0.00002348}{0.000006457} = 3.7$$

Question 7

Answer: B

Explanation:

$Ft = m\Delta v$

$F \times 2 \times 10^{-3} = 1.2(6 - -8)$

$F = 8400 = 8.4$ kN

Question 8

Answer: A

Explanation:

$\sum F = mg$

$mg = (4m + m)a$

$$a = \frac{g}{5}$$

Question 9

Answer: A

Explanation:
The Michelson Morley experiment was designed to measure the speed the Earth moves through the aether

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Question 10

Answer: B

Explanation:

$$\frac{N_p}{N_S} = \frac{V_P}{V_S} = \frac{20}{1}$$

So $V_s = \frac{N_S}{N_P} \times V_P = \frac{1}{20} \times 240$ = 12 V AC RMS

Question 11

Answer: D

Explanation:
When a sound wave is moving towards an observer each wave crest is emitted closer to the observer hence takes less time, this leads to a perceived increased frequency.

Question 12

Answer: B

Explanation:
An electromagnetic wave can be created by accelerating charges.

Question 13

Answer: C

Explanation:
$\sin\theta_c = \frac{n_r}{n_i} = \frac{1}{1.8}$
$\theta_c = 33.75°$

Question 14

Answer: D

Explanation:
$v = f\lambda$
$3.0 \times 10^8 = f \times 2.75 \times 10^{-8}$
$f = 1.09 \times 10^{16}$Hz

Question 15

Answer: C

Explanation:
An electron is a particle. In order to form a standing wave around a nucleus it has a number of wavelengths equivalent to the circumference of the nucleus.

Question 16

Answer: D

Explanation:
The uncertainty principle says that we cannot measure the position and the momentum of a particle with absolute precision. Hence if we cannot measure position or momentum with absolute precision in the present its impossible to predict the future.

Question 17

Answer: D

Explanation:
Laser light is in phase, monochromatic and narrow

Question 18

Answer: C

Explanation:
Sound waves due to their longitudinal nature cannot be polarized.

Question 19

Answer: A

Explanation:
Systematic errors are instrumental errors

Question 20

Answer: B

Explanation:
The independent variable is changed within an experiment to lead to a change that can be measured in the dependent variable.

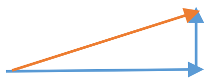
SECTION B – Short Answer

Question 1 (3 mark)

$E_{Q1} = \frac{kq}{r^2} = \frac{9.0\times10^9\times5\times10^{-9}}{0.5^2} = 180$ N C^{-1} vertical

$E_{Q2} = \frac{kq}{r^2} = \frac{9.0\times10^9\times8\times10^{-9}}{1.2^2} = 50$ N C^{-1} horizontal

Vector addition:



$E = \sqrt{180^2 + 50^2} = 186.8$ N C^{-1}

3 marks

Question 2 (6 marks)

a. $E = \frac{V}{d}$

$400 = \dfrac{V}{0.2}$

$V = 80$ V

2 marks

b. $F = Eq = 400 \times 2 \times 10^{-9} = 8 \times 10^{-7}$N

2 marks

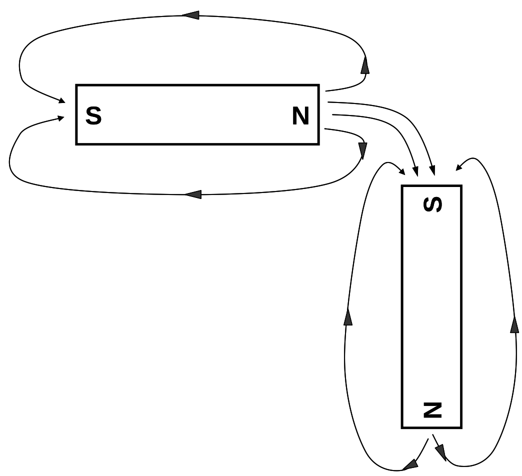
c. $E = \frac{V}{d}$

$E = \frac{80}{0.3} = 266.67$ N C^{-1}

2 marks

Question 3 (4 marks)

a.



Field lines must be continuous, starting from a North pole and finishing at a South pole.

2 marks

b. *Answer*: D

Explanation: Use RH Grip rule for the wire

2 marks

Question 4 (9 marks)

a. g = $\frac{GM}{r^2} = \frac{6.67\times10^{-11}\times6.42\times10^{23}}{(3.4\times10^6)^2} = 3.70\ Nkg^{-1}$

2 marks

b. 687.5 days $= 687.5\times24\times60\times60$
$= 5.94\times10^7\ s$

1 mark

c. Acceleration of Mars around Sun

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

$= \frac{4\pi^2\times2.28\times10^{11}}{(5.94x10^7)^2}$

$= 2.55\times10^{-3}\ m/s^2$

$g = \frac{GM}{r^2}$

$2.55\times10^{-3} = \frac{6.67\times10^{-11}\times M}{(2.28\times10^{11})^2}$

$M = 1.99\times10^{30}\ kg$

Hence mass of Sun is $1.99\times10^{30}\ kg$

3 marks

d. $T = 24\times60\times60+39\times60 = 88740s$

$r^3 = \frac{GMT^2}{4\pi^2}$

$= \frac{6.67\times10^{-11}\times6.42\times10^{23}\times88740^2}{4\pi^2}$

$= 8.54\times10^{21}$

So $r = 2.04\times10^7\ m$

$= 2.04\times10^4\ km$

Hence distance above planet surface:

$= 2.04\times10^4\ km - 3.4\times10^3\ km$

$= 1.7\times10^7\ m$

3 marks

Question 5 (8 marks)

a. Vertical component of velocity = 50 sin 60°
= 43.3 m/s

In vertical direction,

$v = u + at$

$0 = 43.3 + -9.8t$

$t = 4.42\,s$

Hence total time of flight $= 2t = 2 \times 4.42 = 8.84\,s$

3 marks

b. Horizontal component of velocity = 50 cos 60°
= 25 m/ s

In horizontal direction,

$d = vt$

$d = 25 \times 8.84$

$d = 221m$

2 marks

c. Acceleration = g = 9.8 m/s^2 down

2 marks

d. Air resistance would reduce the range of the golf ball.

1 mark

Question 6 (9 marks)

a. Given that the collision is isolated, we can assume momentum is conserved
Total momentum before the collision = Total momentum after the collision
If East is assigned as positive momentum:
$+0.03 \times 3 + 0 = -0.03v + +0.08 \times 1.5$
v = 1 m/ s West

3 marks

b. Change in momentum of blue ball = Final Momentum – Initial Momentum
= $+0.08 \times 1.5 - 0$
= +0.12 kg m/ s

Ft = Change in momentum
$F \times 0.15 = +0.12$
$F = 0.8N$ East
Average force exerted by blue ball on red ball is 0.8 N East.

3 marks

c. The collision is inelastic.

Total Kinetic Energy before collision = $0.5 \times 0.03 \times 3^2$
$= 0.135J$
Total Kinetic Energy after collision = $0.5 \times 0.03 \times 1^2 + 0.5 \times 0.08 \times 1.5^2$
$= 0.105J$
Since Total Kinetic Energy before collision > Total Kinetic Energy after collision the collision is inelastic.

3 marks

Question 7 (3 marks)

a. 20 km/ hr $= \frac{20}{3.6}$ m/s
= 5.6 m/s

1 mark

b. Net Force $= \frac{mv^2}{r}$
$= \frac{1200 \times 5.6^2}{3.5}$
= 1.08×10^4 N towards the centre

2 marks

Question 8 (4 marks)

a. $F = m_a g + m_b g = 1.6N$
Newton's First Law

2 marks

b. *0 N*
All of three books free fall. There is no force acting between the books.

2 marks

Question 9 (7 marks)

a. Time = $\frac{d}{s}$ = $\frac{5.9\times10^{12}}{0.3\times3\times10^{8}}$ = 65 555.6 *s* = 18 hrs 12 mins 35.6 *s*.
Hence Daisy's watch would read 6:12:36 am.

2 marks

b. $\gamma = \frac{1}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ and

$$t = t_0\gamma$$

Substitute *v* with 0.3*c* and solve for γ = 1.0483
Hence Donald would measure a time of $\frac{65555.6}{1.0483}$ = 62 537.0 *s* or 17 hours 22 mins 17.0 *s*.
Hence Donald's watch would read 5:22:17 am.

3 marks

c. Length = $\frac{L_o}{\gamma}$ = $\frac{7}{1.0483}$ = 6.68 m

2 marks

Question 10 (5 marks)

a. $F = nBIL$
$8.1\times10^{-2} = n\times0.3\times0.03\times0.1$
$n = 90\,turns$

2 marks

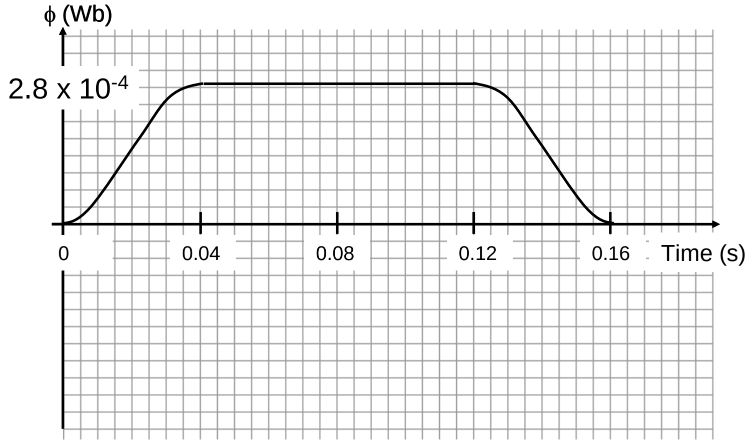
b.

FORCE on SIDE AB	FORCE on SIDE BC	CURRENT in SIDE AB
No change	Decreased (zero at vertical)	Increased (zero at horizontal)

3 marks

Question 11 (6 marks)

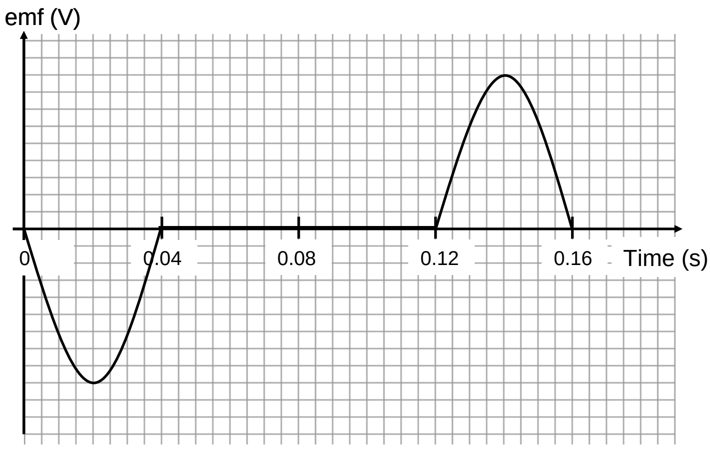
a.



$$\Phi_{max} = BA = 0.4 \times \pi \times 0.015^2 = 2.8 \times 10^{-4} Wb$$

2 marks

b.



The emf is the negative gradient function of the flux curve, due to $emf = -n\dfrac{\Delta\phi}{\Delta t}$

2 marks

c. *Answer:* C

Explanation:

Use $emf = -n\dfrac{\Delta\phi}{\Delta t}$

$$0.353 = -n\frac{2.8\times10^{-4}}{0.04}$$

$$n = 50$$

2 marks

Question 12 (10 marks)

a. Clockwise.

Consider a positive charge at A. If the turbine spins clockwise, at the instant shown, the positive charge will be rising. The RH slap rule shows that the charge will be pushed (by an induced force) from A to B as required. (Note: The pushing of the charge is the induced current)

3 marks

b. The slip rings are permanently connected to opposite sides of the coil, so as the induced current alternates in direction, the slip rings carry this alternating current to the external circuit.

2 marks

c. This setup is a **generator**, as the coil is rotating within a magnetic field. An **alternator** is similar, but the magnet rotates inside stationary coils, where current is induced.

3 marks

d. A transformer requires alternating current because it relies on the transfer of constantly changing flux (which is created in the primary coil by the alternating input current). This flux is carried by a central iron core and induces voltage and current in the secondary circuit. DC current will not work because it will only lead to a constant magnetic field and thus no change in flux.

2 marks

Question 13 (9 marks)

a.

$$V_{peak} = 400 \times \sqrt{2}$$
$$V_{peak} = 566V$$

2 marks

b.

$$I_{RMS} = \frac{P}{V_{RMS}}$$
$$I_{RMS} = \frac{2500}{400}$$
$$I_{RMS} = 6.25\,A$$
$$I_{peak-peak} = I_{RMS} \times 2\sqrt{2}$$
$$I_{peak-peak} = 17.7\,A$$

2 marks

c.

$$V_{drop} = IR$$
$$V_{drop} = 6.25 \times 4$$
$$V_{drop} = 25V$$

2 marks

d. An increase in current in the shack will lead to an increase in the current in the cables. This will lead to a larger voltage drop in the cables and thus a smaller V_{PRIM}. When stepped down, this will make V_{SEC} less than 110 V.

3 marks

Question 14 (4 marks)

Source of Light	Spectrum (Continuous / Discrete)	Nature of Phase (Coherent / Incoherent)	Electron behaviour (Thermal motion / Quantised energy level)
LASER	Discrete	Coherent	Quantised energy level
Candle	Continuous	Incoherent	Thermal motion
Metal Vapour Lamp	Discrete	Incoherent	Quantised energy level
Incandescent Globe	Continuous	Incoherent	Thermal motion

Question 15 (13 marks)

a. $v = f\lambda$
$3.0 \times 10^8 = 4.14 \times 10^{14} \times \lambda$
$\lambda = 7.25 \times 10^{-7} m$

2 marks

b. Independent = wavelength of laser light
Dependent = path difference

2 marks

c. Obtain the red laser and the double slit.
Set the double slit up at a set distance from a screen
Shine the laser light through the double slit and observe the interference pattern formed on the screen.

2 marks

d. $pd = n\lambda = 2 \times 7.25 \times 10^{-7} = 14.49$ nm

2 marks

e. Systematic – laser
Random – measurement

2 marks

f. $pd = \left(n - \frac{1}{2}\right)\lambda$
14.49 nm = 1.5λ
$\lambda = 9.66 \times 10^{-7}$m
$v = f\lambda$
$3.0 \times 10^8 = f \times 9.66 \times 10^{-7}$
$f = 3.1 \times 10^{14}$ Hz

3 marks

Question 16 (6 marks)

a. $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{380 \times 10^{-9}} = 1.74 \times 10^{-27}$ kgms^{-1}

2 marks

b. $p = \sqrt{2mKE} = \sqrt{2 \times 9.1 \times 10^{-31} \times 1.3 \times 1.6 \times 10^{-19}} = 6.15 \times 10^{-25}\ kgms^{-1}$

2 marks

c.

$$V = hf - hf_o$$

$$1.3 = 4.14\times10^{-15}\times\frac{3\times10^{8}}{380\times10^{-9}} - 4.14\times10^{-15}\times f_o$$

$$f_o = 4.75\times10^{14}\ Hz$$

2 marks

Question 17 (4 marks)

a. Check each wavelength to determine its Energy value: $E = \frac{hc}{\lambda}$

776 nm = 1.6 eV (No corresponding energy gap)
591 nm = 2.1 eV (drop from 4 to 3)
185 nm = 6.7 eV (drop from 3 to 1)
226 = 5.5 eV (No corresponding energy gap)

2 marks

b. Electrons will only exist at energy levels which correspond to standing waves (the wavelength for this is derived from their de Broglie wavelength). From the energy level diagram, it appears that the 4.5 eV (276 nm) level is not viable for this particular atom.

2 marks
