PHYSICS

Unit 2 – Written examination

2018 Trial Examination

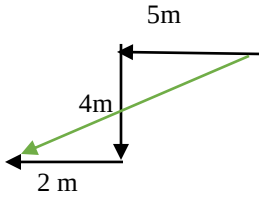
SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: B

Explanation:



$resutlant = \sqrt{7^2 + 4^2} = 8.06$ m

$angle = 90 - \tan^{-1}\left(\frac{4}{7}\right) = 90 - 29.77 = 60.26°$

Question 2

Answer: D

Explanation:

There 275 km in 3 hours
Back 275 km in 3 hours 45 minutes

$velocity\ there = \frac{275}{3} = 91.66$ km h^{-1}
$velcoity\ back = \frac{275}{3.75} = 73$ km h^{-1} = 22.63 m s^{-1}

$overall\ velocity = \frac{550}{6.75} = 81.5$ km h^{-1}

Question 3

Answer: C

Explanation:
$displacement =\ area\ under\ the\ graph\ at\ t = 7 = \frac{1}{2} \times 3 \times 2 + 2 \times 3 + \frac{1}{2} 3 \times 3 = 13.5$ m
$at\ t = 2s\ the\ child\ has\ constant\ velocity$
$Maximum\ acceleration = \frac{3}{2} = 1.5$ m s^{-2}

Question 4

Answer: D

Explanation:
$From\ t = 7 - 10\ displacement = \frac{1}{2} \times 2 \times 2 + 2 \times 1 = 4$ m

$overall\ displacement = 13.5 - 4 = 9.5$ m

Question 5

Answer: B

Explanation:
$v = u + at$
$22.2 = 13.89 + a \times 3$
$a = 2.78$ m s^{-2}

Question 6

Answer: C

Explanation:
$F = ma = 2 \times 10 = 20$ N
$20 = m \times 4$
$m = 4$ kg

Question 7

Answer: B

Explanation:
$N = W \cos\theta$
An increase in angle will therefore decrease the normal reaction force

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Question 8

Answer: D

Explanation:
$\Delta\rho = mv = 1.5 \times 8 = 12$ kg m s^{-1}
$12 = 55 \times v$
$v = 0.22$ m s^{-1} in the opposite direction

Question 9

Answer: A

Explanation:
$5 \uparrow -6 \downarrow = 11$ m s$^{-1}\uparrow$
$Ft = m\Delta v$
$F \times 20 \times 10^{-3} = 0.5 \times 11$
$F = 275$ N

Question 10

Answer: A

Explanation:
$mg\Delta h = 60 \times 9.8 \times 5 = 2940$ J
$efficiency = \frac{useful\ energy}{total\ energy}$
$0.8 = \frac{2940}{total}$
$total = 3675$ J

Question 11

Answer: c

Explanation:
$mg\Delta h = 500 \times 9.8 \times 10 = 49000$ J
$energy = Ek + GPE$
$49000 = 500 \times 9.8 \times 7.5 + Ek$
$Ek = 122500$ J

Question 12

Answer: B

Explanation:
$average\ time = \frac{0.33+0.54+0.45+0.28+0.47}{5} = 0.414$ s
Smallest increment = 0.01 s
Uncertainty = ± 0.005s

Question 13

Answer: C

Explanation:
A change in the independent variable will see an associated change in the dependent variable – hence the independent variable is the manipulated variable

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Question 14

Answer: C

Explanation:
An hypothesis can be tested, it is a prediction and should be based on theoretical information

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Question 15

Answer: A

Explanation:
Worn out equipment will lead to a systematic error.

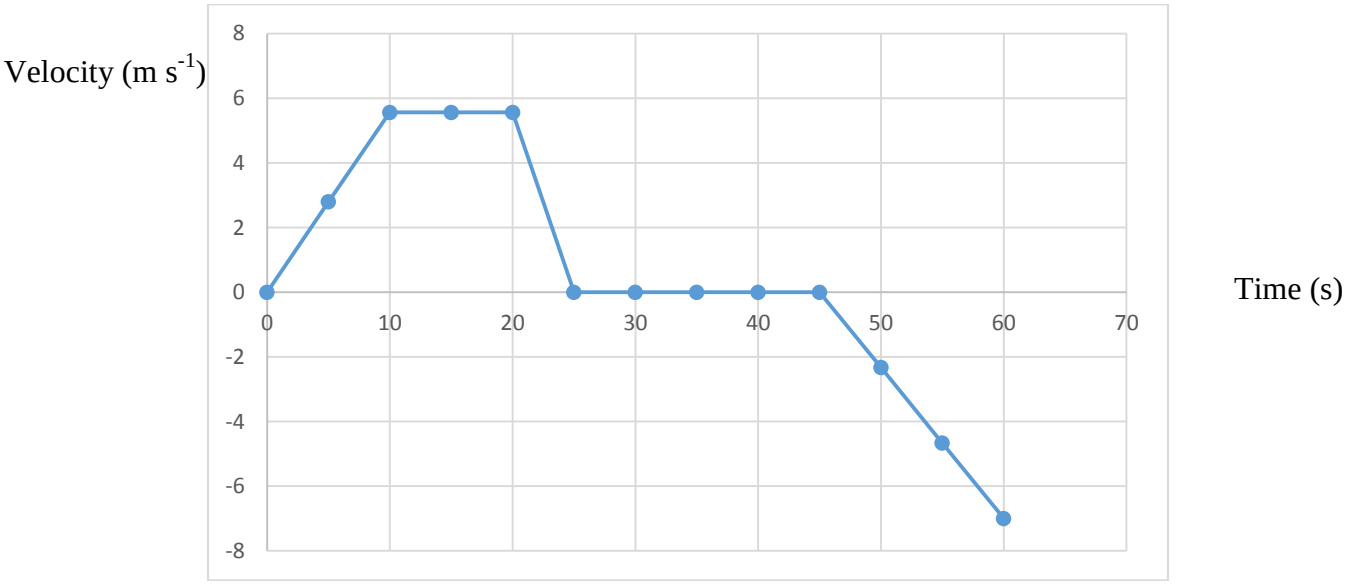
SECTION B: CORE Short-answer questions

Question 1 (10 marks)

a. $v = u + at$
$5.56 = 0 + a \times 10$
$a = 0.56$ m s^{-2}

2 marks

b.



3 marks

c. $displacement\ on\ initial\ journey = \frac{1}{2} \times 5.56 \times 10 + 5.56 \times 10 + \frac{1}{2} \times 5.56 \times 5 = 97.3$ m
$displacement\ on\ return\ journey = \frac{1}{2} \times 7 \times 15 = 52.5$ m

$overall\ displacement = 97.3 - 52.5 = 44.8$ m north

3 marks

d. $v = u + at$
Slowing down
$0 = 5.56 + a \times 5$
$a = -1.11$ m s^{-2}

On the return journey
$7 = 0 + a \times 15$
$a = 0.47$ m s^{-2}

Hence a deceleration of 1.11 m s^{-2} is the greatest

2 marks

Question 2 (7 marks)

a. $Ft = m\Delta v$
$F \times 10 \times 10^{-3} = 0.15(\overrightarrow{15} - \overleftarrow{10})$
$F \times 10 \times 10^{-3} = 0.15(\overrightarrow{25})$
$F = 375$ N

2 marks

b. $s = ut + \frac{1}{2}at^2 = 0 \times 0.55 + \frac{1}{2} \times 9.8 \times 0.55^2 = 1.48$ m

2 marks

c. $Final\ velocity\ vertically$
$v = u + at = 0 + 9.8 \times 0.55 = 5.39$ m s^{-1}
$Final\ velocity\ horizontally = 15$ m s^{-1}
$Resultant\ velocity = \sqrt{5.39^2 + 15^2} = 15.94$ m s^{-1}

3 marks

Question 3 (5 marks)

a. $Driving\ force = force\ acceleration + friction$
$4000 = (500 + 600)a + (1500 + 600 \times 3)$
$a = 0.64$ m s^{-2}

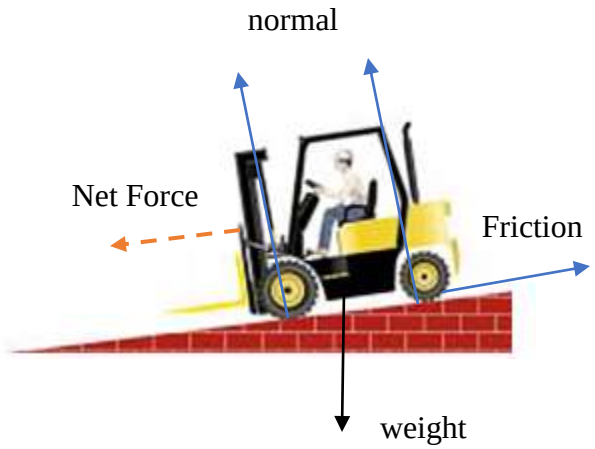
3 marks

b. $Tension = Force\ acceleration + Friction$
$T = 600 \times 0.64 + 600 \times 3 = 2184$ N

2 marks

Question 4 (6 marks)

a.



2 marks

b. actual

$v = u + at$

$3 = 0 + a \times 10$

$a = 0.3 \text{ m s}^{-2}$

Theoretical

$a = g \sin\theta = 9.8 \sin 15 = 2.53$

Frictional force

$F = ma = 1000(2.53 - 0.3) = 2230 \text{ N}$

4 marks

Question 5 (5 marks)

a. $\sum F = 110 \times 9.8 \downarrow -80 \times 9.8 \uparrow = 294 \text{ N}\downarrow$

$F = ma$

$294 = (110 + 80)a$

$a = 1.55 \text{ m s}^{-2}$

3 marks

b. $\sum F = W + T$

$80 \times 1.55 \uparrow = 80 \times 9.8 \downarrow + T$

$T = 908 \text{ N}$

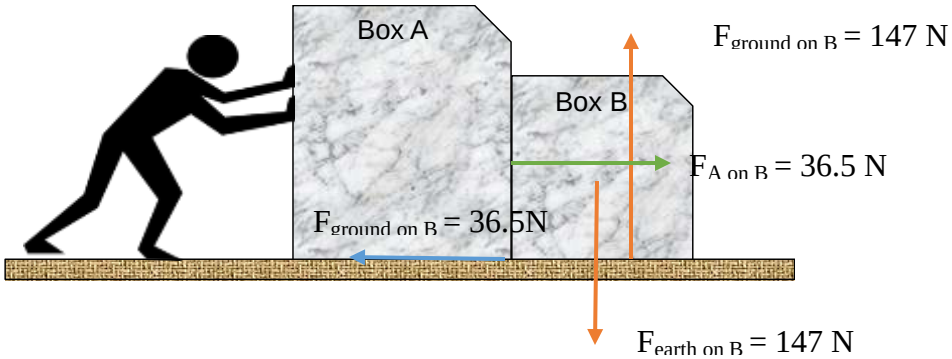
2 marks

Question 6 (7 marks)

a. Forces in all directions should be balanced as both Boxes are travelling at a constant speed.
Thus: $F = 0.25 \times 9.8 \times 30 + 0.25 \times 9.8 \times 15 = 110.25$ N

2 marks

b.



2 marks

c. $F_{A\ on\ B}$ = 36.5 N to the right – hence due to Newton's 3rd law the forces are balanced therefore 36.5 N to the left

3 marks

Question 7(15 marks)

a. Within this experiment the two carts will experience a collision which is locked. The momentum within the collision will be conserved and the kinetic energy will be transformed to other energy formats hence an inelastic collision

3 marks

b. Independent variable – initial velocity of carts 1 and 2
Dependent variable – final velocity of carts 1 and 2
Controlled variable – mass of carts 1 and 2

3 marks

c. $m_1u_1 \pm m_2u_2 = (m_1 + m_2)v$
$2.5 \times 5 - m_2 \times 8 = (2.5 + m_2) \times 2.1$
$12.5 - 8m_2 = -5.25 - 2.1m_2$
m_2 =3 kg

2 marks

d. $\rho_{inital} = 2.5 \times 5 - 3 \times 8 = 11.5$ m s^{-1} left
$\rho_{final} = 3 \times 2.1 = 6.3$ m s^{-1} left
Momentum has therefore been lost – due to possibly unaccounted for friction or errors within the timing and hence the velocities of the carts.

2 marks

e. $Ek_{before} = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 = \frac{1}{2} \times 2.5 \times 5^2 + \frac{1}{2} \times 3 \times 8^2 = 127.5$ J
$Ek_{after} = \frac{1}{2}(m_1 + m_2)v^2 = \frac{1}{2} \times (2.5 + 3) \times 1.5^2 = 6.19$ J
Collision is inelastic as $Ek_{before} > Ek_{after}$

3 marks

f. Systematic errors could include issues within the equipment used to measure the velocity such as issues in the timing mechanism
Random errors could include distances not measured accurately by students in order to calculate the velocities correctly

2 marks

Section C: Options

Option 1 : What are stars

Question 1

Answer: D

Explanation: A group of stars in close proximity to each other is called a cluster.

Question 2

Answer: A

Explanation: In the visible region of the electromagnetic spectrum red light has wavelengths of between 620 nm and 750 nm.

Question 3

Answer: C

Explanation: According to the Doppler effect a Galaxy heading towards us would have the Hydrogen emission lines of its spectra blue-shifted or shortened. Choice C correctly shows this shortening.

Question 4

Answer: D

Explanation:

Einstein's theory of relativity showed when a massive stars dies it leaves behind a small dense remanent core which produces a black hole.

Question 5

Answer: D

Explanation: No light – light can't escape a black hole.

Question 6 (9 marks)

a. A star is a luminous ball of gas, which is mainly hydrogen and helium which is held together by its own gravity

2 marks

b. Nuclear fusion reactions cause four hydrogen atoms to fuse to form helium. This releases photons of energy in the form of heat and light (1 mark)

2 marks

c. A star's apparent brightness is its brightness seen from Earth
A star's absolute brightness is the brightness the star would have if it were a standard distance of 32.6 light years from Earth

2 marks

g. Within a main sequence star nuclear fusion occurring, this results in atoms being pushed away from the centre of the star, at the same time this is counter balanced by the star's gravitational forces pulling atoms towards the centre of the star.

3 marks

Question 7 (6 marks)

a. A Hertzsprung-Russell diagram plots the star's luminosity against its absolute magnitude. From the position of a star within the diagram astronomers can make assumptions about a stars internal structure and its evolutionary stage.

2 marks

b. Stars in the upper right are known as supergiants. They have high luminosity but lower temperatures.

2 marks

c. Cooling moves the star upwards on the HR graph. More luminous moves it to the right.

2 marks

Section C: Options
Option 2 : Is there life beyond the solar system?

Question 1

Answer: D

Explanation: In order for a habitable zone to exist around a star there it must be the right size and temperature

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Question 2

Answer: B

Explanation: Measured wavelength is shorted than known wavelength, hence an indication that the star is moving towards Earth

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Question 3

Answer: C

Explanation: $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

$\frac{397.2-390.4}{397.2} \times 3 \times 10^8 = v$

$v = 5.1 \times 10^6$ m s^{-1}

Question 4

Answer: D

Explanation: Fermi paradox measures the number of advanced civilisations in our galaxy

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Question 5

Answer: C

Explanation: The sun's spectrum is a continuous spectrum displaying absorption lines

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Question 6 (9 marks)

a. Spectroscopy can be used to determine the surface temperature is calculated using the wavelength of the maximum emission from the star. The rotational velocity is determined from the Doppler lines in the spectrum and the chemical composition is determined from the spectral lines that are present which represent the characteristics of the elements.

3 marks

b. The first spectrum is a continuous spectrum – it is caused by white light dispersing into the ROYGBIV colours. The second spectrum is an absorption spectrum caused when atoms absorb particular photons allowing electrons to jump to a higher state. The lines indicate wavelengths of absorbed photons. The third spectrum is opposite to the second, it is an emission spectrum where electrons have become excited and are emitting photons of particular wavelengths to return to the ground state.

3 marks

c. The differences within the spectrum are within the absorption lines. The second spectra shows lines that have been shifted towards the blue end. This indicates that the wavelengths are perceived to be shortening hence indicating that the object that has produced this spectra is moving toward us.

3 marks

Question 7 (6 marks)

a. Liquid water is the first thing scientists look for when looking for life outside of Earth as all living things needs water in order to be able to survive.

2 marks

b. Temperature is determined by the distance to a parent star and the parent stars luminosity. If it's too far away it becomes too cold for liquid water (or if it is too close the water will evaporate away).

2 marks

c. The two other properties scientists look for are the presence of carbon and the size of the planet. Molecules that make up life on Earth are carbon based – forming organic molecules. In regards to the size of the planet, larger planets have a greater gravitational force therefore unlikely to have life similar to earth.

2 marks

Section C: Options

Option 3 : How do forces act on the human body?

Question 1

Answer: C

Explanation: The elbow is an example of a third class lever as the load is generally in your hand and your muscles, which provide the force to lift it, act between the load and the elbow joint which is the fulcrum.

Question 2

Answer: A

Explanation: As Kristina raises her arms above her head she has created a situation where she has more mass above the current centre of mass, hence the new centre of mass will move up.

Question 3

Answer: A

Explanation: $x_{com} = \frac{mx_1 + mx_2}{m_1 + m_2}$

Second distance = 11 + 6.4 = 17.4

$x_{com} = \frac{0.81 \times 11 + 0.33 \times 17.4}{0.81 + 0.33}$

$x_{com} = 12.9$ cm from elbow

Question 4

Answer: D

Explanation: $Stress = \frac{F}{A}$

$Stress = \frac{2250}{2.5 \times 10^{-4}} = 9 \times 10^6$ Pa

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Question 5

Answer: C

Explanation: Strain energy per unit volume equals area under the graph.

$$7\ squares\ \times 70 \times 10^{6}\ \times 0.005 = 2.45 \times 10^{6}\ \text{J m}^{-3}$$

Question 6 (12 marks)

a. $Torques\ up = Torques\ down$

$F_{arm}d + F_{toes}d = F_{weight}d$

$F_{arm} \times 1.5 + F_{toe} \times 0 = 50 \times 9.8 \times (1.5 - .85)$

$F_{arm} = 212.33$ N

3 marks

b. $\tau_{muscle} = \tau_{arm}$

$F \times 1.5 = 106.17 \times 25$

$F = 1769.5\ N$

3 marks

c. $F_{arm} + F_{toe} = F_{weight}$

$212.33 + F_{toe} = 490$

$F_{toe} = 277.7$ N

1 mark

d. Assuming all *GPE* is converted to work in the knee joint

$m \times g \times h = Fd$

$50 \times 9.8 \times 2 = F \times 0.01$

$F = 9.8 \times 10^{4}$ N

3 marks

e. $\sigma = \frac{F}{A}$

$\sigma = \frac{49000}{0.00033}$

$\sigma = 1.5 \times 10^{8}\text{Nm}^{-2}$

2 marks

Question 7 (3 marks)

Material	Location of Use	Properties that make it suitable
Aluminum	*Limbs*	*Equal in strength and stiffness to bone lightweight*
Silicon	*Joints*	*carries little weight can be bent and stretched without breaking and provides flexibility*
Ultrahigh molecular weight polyethylene	*Cartilage surrounding ball and socket joints*	*Biocompatibility with surrounding tissue, low friction , durable*

Section C: Options

Option 4: How can electricity charge a DC device?

Question 1

Answer: C

Explanation: $\frac{V_2}{V_1} = \frac{N_2}{N_1}$

$N_2 = 8 \times N_1$
$V_2 = 8 \times V_1$
$V_2 = 8 \times 240$
$V_2 = 1920$ V.

Question 2

Answer: B

Explanation: $V_1 I_1 = V_2 I_2$
$240 \times 4.5 = 1920 \times I_2$
$I_2 = 0.56$ A

Question 3

Answer: C

Explanation: Battery supplies 10V and the diode has a switch on of 1V.

$Resistor = 10 - 1 = 9$ V

Question 4

Answer: B

Explanation: Voltage R_L same as the diode = 5V
Current $R_1 = \frac{10-5}{50} = 0.1$ A
Current R_L = 0.1-0.04 = 0.06
Resistance $R_L = \frac{5}{0.06} = 83\ \Omega$

Question 5

Answer: B

Explanation: Capacitor discharges quickly for a shorter time to give a steady output voltage

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Question 6 (6 marks)

a. 500 Ω

1 mark

b. $V_{out} = \frac{R_{out}}{R_{total}} \times V_{in}$

$5 = \frac{2000}{R_v + 2000} \times 12$

$R_v = 2850\ \Omega$

2 marks

c. At 5℃, the resistance of the thermistor has increased to 5000 Ω
In order to keep the ratio the same, the value of the variable resistance must also increase.

3 marks

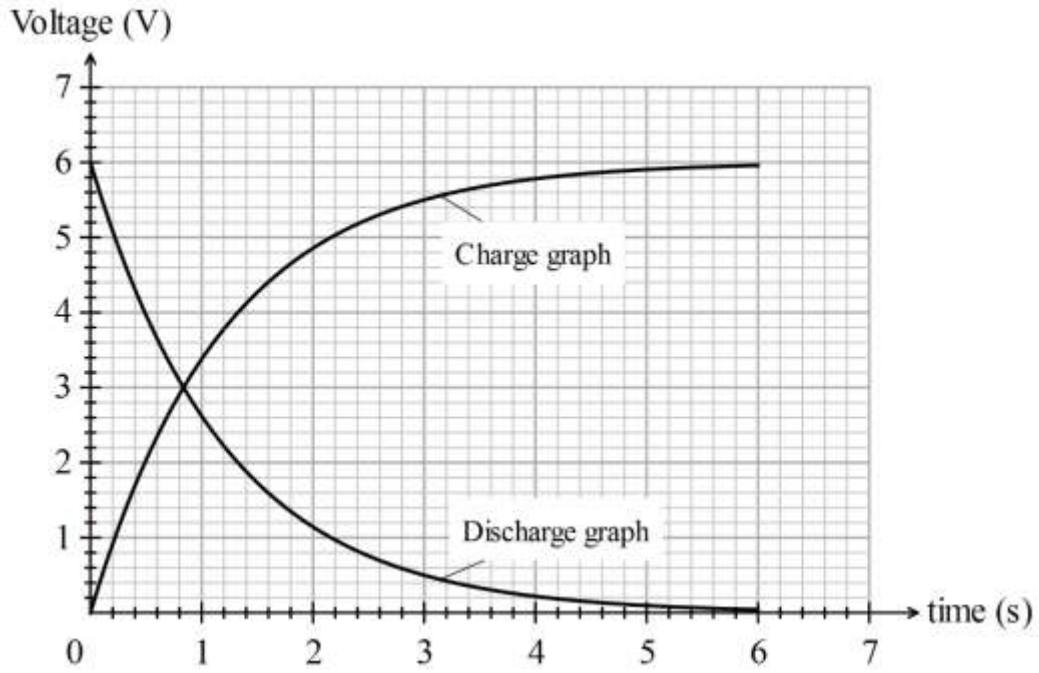
Question 7 (9 marks)

a. $\tau = RC$
$\tau = 3000 \times 400 \times 10^{-6}$
$\tau = 1.2$ s

2 marks

b. See graph
Charging curve correct and labelled
V after 1 time constant is 63% of 6 V

2 marks



c. After 1.2 s, the capacitor is 63% charged
63% of voltage across the capacitor = 3.78V
Voltage across R = 6 – 3.78 = 2.22 V

2 marks

d. See graph above
Discharge curve correct and labelled.
V after 1 time constant is 37% of 6 V

2 marks

Section C: Options

Option 5: How do heavy things fly?

Question 1

Answer: D

Explanation: Lift and drag are independent of one another

Question 2

Answer: B

Explanation: A small increase in the angle of attack increases lift

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Question 3

Answer: B

Explanation: Aircraft travelling horizontally at a constant speed so, thrust force = drag force

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Question 4

Answer: C

Explanation: W (Lift force) = m × g (weight force)

$$W = 5 \times 10^5 \times 9.8$$
$$W = 4.9 \times 10^6 \text{ N}$$

Question 5

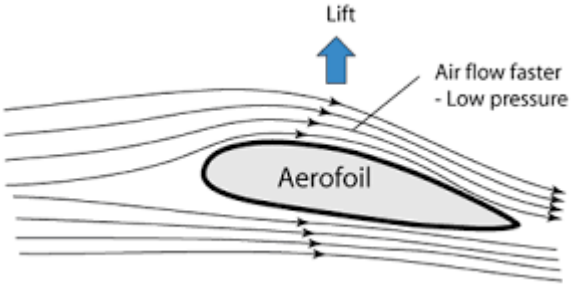
Answer: A

Explanation: $P = F\ v$

$$\frac{80\,000 \times 750}{3.6} = 1.67 \times 10^7\ W$$

Question 6 (10 marks)

a.



Angle of attack

3 marks

b. Air travelling over the top speeds up therefore creates a region of lower air pressure. Air travelling underneath travels slower compared to the top hence higher pressure – creates lift

2 marks

c. Angle of attack is the angle between an aircraft's leading edge chord line and the aircraft's flight path. Angle of attack can change the amount of lift and drag due to the distance the air needs to travel over the top of the wing.

2 marks

d. Induced drag; due to the 3D nature of the wing, tip of the wing creates a different air pressure between the lower and upper surface which creates a vortex. Vortex creates a proportional lift force acting to oppose the forward motion
Parasitic Drag; skin friction – caused by contact between the air and the surface of plane – worse when surface dirty and form drag – due to shape of the surface – has improved with increased aerodynamic principles

3 marks

Question 7 (5 marks)

a. $\sum F = 100\,000 - 75\,550 = 24\,450$ N
$F = ma$
$24\,450 = 13\,155a$
$a = 1.86$ m s^{-2}

2 marks

b. $\tau_L = \tau_R$
$Fd_L = Fd_R$
$500 \times 9.8 \times 2.4 = m \times 9.8 \times 4.6$
$m = 260.9 = 260.9$ L

3 marks

Section C: Options

Option 6: How do nuclear fission and fusion compare as viable energy sources?

Question 1

Answer: A

Explanation: $235 - 92 = 143$, therefore there are 143 neutrons, 92 protons and 235 nucleons

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Question 2

Answer: A

Explanation: Mass number $1 + 235 = 236 - (4 \times 1 + 140) = 92$
Atomic number $92 - 55 = 37$

Question 3

Answer: D

Explanation: $E = mc^2$
$2.5 \times 10^{34} \times 1.6 \times 10^{-19} = m \times (3 \times 10^8)^2$
$m = 0.044$ kg

Question 4

Answer: B

Explanation: The main fuel used within a fusion reaction is deuterium which is an isotope of hydrogen

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Question 5

Answer: C

Explanation: The process by which two lighter nuclei travelling at high speeds fuse together to form a single heavier nuclei is called nuclear fusion

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Question 6 (5 marks)

a. Fission fuel consists of very large nuclei (such as uranium) and involves the splitting of a nucleus into 2 or more smaller nuclei
Fusion fuel consists of very small nuclei (such as hydrogen) and is the joining of 2 or more of these nuclei to form a larger one

3 marks

b. Fusion reactors require very high temperatures and very high pressure in order to achieve fusion. Currently this can only be achieved for a short period of time, hence they require a lot more energy to fuse than what they are able to create. As a result, Fission reactors are the more viable source of nuclear energy production.

2 marks

Question 7 (10 marks)

a. Fission reaction.

1 mark

b. ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3\,{}^{1}_{0}n$

2 marks

c. One neutron causes the uranium nucleus to split releasing 2 other neutrons. These product neutrons can then potentially combine with other uranium nuclei and cause fission and so the process continues.

2 marks

d. The concentration of U-235in the uranium fuel - If it is too low a chain reaction is not sustained. Shape – if it is flat the surface area to volume ratio is too large so too many neutrons escape into the air and fission will not continue

2 marks

e. Reactants mass = $3.9195225 \times 10^{-25}$
Products mass = $3.9196685 \times 10^{-25}$

Δ mass = 2.84×10^{-28} kg

$E = mc^2$
$E = 2.84 \times 10^{-28} \times (3 \times 10^{8})^2$
$E = 2.55 \times 10^{-11}$ J

3 marks

Section C: Options

Option 7: How do nuclear fission and fusion compare as viable energy sources?

Question 1

Answer: C

Explanation: Magnetic resonance imaging (MRI) can be carried out using elements that have an odd number of nucleons. The most abundant isotopes of Carbon, Oxygen and Calcium all have an even number of nucleons. The most abundant form of Hydrogen has only one nucleon making it the most suitable for MRIs.

Question 2

Answer: C

Explanation: 5 half lives in order to have correct amount on delivery. 0.5-1-2-4-8-16 MBq

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Question 3

Answer: A

Explanation: A positron is identical to an electron, but has a positive charge.

Question 4

Answer: B

Explanation: Very soon after it is emitted a positron will meet an electron and be annihilated with it. This means that the positron and electron are destroyed and gamma rays are emitted.

Question 5

Answer: C

Explanation: The two emitted gamma rays are at 180^{o} to each other.

Question 6 (5 marks)

a. Radioactive isotopes must have a half-life that is long enough to allow them to accumulate in the target organ, so that an image can be produced, yet short enough so that the exposure of the person to radioactivity is minimised to reduce harm to healthy tissue.
Radioisotopes must also emit appropriate types of radiation. Alpha and beta particles do not penetrate the body and are unsuitable for medical imaging

3 marks

b. Fluorine-18. Fluorine-18 being a positron emitter can be used in a PET scanner
Technetium-99 being a gamma emitted with a short half-life can be used with a gamma camera.

2 marks

Question 7 (10 marks)

a. X-rays are formed in evacuated glass tubes, where a filament at one end is heated releasing electrons. Electrons are accelerated through tube and strike a metal plate at the other end hence decelerating suddenly – therefore giving off their energy in the form of an X-ray

2 marks

b. Image produced by passing the x-ray photons through the person's body. On its way through the body parts of the energy are attenuated. On the opposite side a photographic captures the attenuated x-rays.

2 marks

c. Bone for absorbs the x-ray appearing white on the film where soft tissue allows some or all to get through hence appearing the lighter grey/black component on the film

2 marks

d. Hard x-rays have a higher frequency and are more penetrating than soft x-rays
Soft x-rays are absorbed by the skin while hard x-rays penetrate skin and are absorbed by bone which is generally what is being imaged. Hence hard x-rays preferred.

2 marks

e. Both CAT scans and X-rays are taken with the same mechanisms as a CAT scan uses X-rays to create the image. X-rays are 2 dimensional and often the image can be obscured by other internal structures such as bones or internal organs. While a CAT scan uses an X-ray machine this machine rotates so there are multiple images collected at different angles and a computer creates a new image removing the structures that are not being examined.

2 marks

Section C: Options

Option 8: How do particle accelerators work?

Question 1

Answer: A

Explanation: A cloud chamber is not a particle accelerator

Question 2

Answer: C

Explanation: The primary purpose of a particle accelerator is to create particles and study their behaviour

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Question 3

Answer: B

Explanation:

$E = qV = 1.6 \times 10^{-19} \times 8000 = 1.28 \times 10^{-15} J$

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

$1.28 \times 10^{-15} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$

$v = 5.3 \times 10^7$ ms^{-1}

Question 4

Answer: C

Explanation: Synchrotron radiation is produced within the infra-red to hard X-rays range– it is therefore not monochromatic. It does have a high brightness, it is tuneable to a single frequency and is highly polarised.

Question 5

Answer: D

Explanation: Particle accelerators are not used in operations of LEDs.

Question 6 (9 marks)

a. Accelerates subatomic particles so they achieve high energies to determine the properties of the particles and their interactions. The charged particles are accelerated between two electrodes that have a potential difference across them this causing the particles to gain energy. The paths of the high speed particles are controlled by magnetic fields.

2 marks

b. The storage ring is the final destination for accelerated electrons. Electrons in the storage ring can travel close to the speed of light for hours and it is where X-rays are produced when electrons interact with different magnetic fields.

2 marks

The linear accelerator or linac accelerates the electrons close to the speed of light. It does this using radiowave energy in short bursts and the electrons pass through a sequence of alternating electric fields.

2 marks

c. Synchrotron produces radiation of wavelengths that are corresponding to the dimensions of cells, viruses, proteins and atoms so X-rays produced are prefect to examine structures at a cellular level. The brightness and coherence enables electron diffraction to reveal the structure of crystals. The energy and collimated nature make it suitable for a wide range of imaging processes such as diagnosis of tumors.

3 marks

Question 7 (6 marks)

a. Gauge boson – particles that enable forces of electromagnetism and strong and weak interactions to be carried between particles such as leptons and hadrons

2 marks

b. Particle accelerators have been significant in the measurement of mass and charge of all these particles thus allowing for the standard model to be confirmed.

2 marks

c. The Higgs boson is the particle that "gives" all other particles mass. Detection of the Higgs boson is challenging as it cannot be stored it decays. It is thought to be the fundamental building block of the universe.

2 marks

Section C: Options

Option 9: How can human vision be enhanced?

Question 1

Answer: B

Explanation: $n_i \sin\theta_i = n_r \sin\theta_r$
$1 \times \sin 40 = 1.58 \sin\theta_r$
$\theta_r = 24°$

Question 2

Answer: D

Explanation: $Power = \frac{1}{focal\ length}$

$Power = \frac{1}{+0.25} = +4$

Question 3

Answer: B

Explanation: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{-20} = \frac{1}{10} + \frac{1}{v}$

$v = -6.67$ cm

Question 4

Answer: A

Explanation: When examining long-sightedness we are examining a hypermetropic eye, where the near point has receded away.

Question 5

Answer: C

Explanation: Lachlan is long sighted hence he will need a convex lens to correct it

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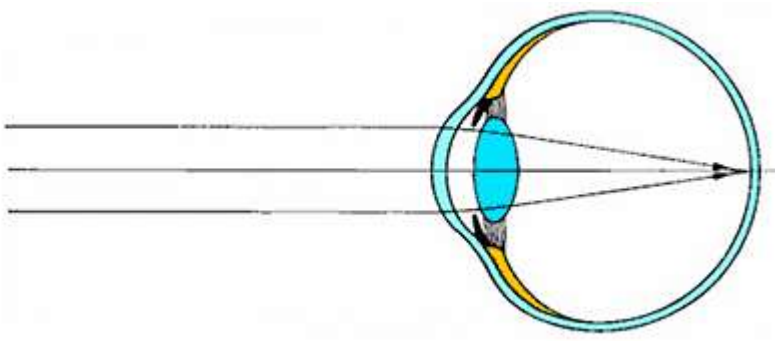
Question 6 (6 marks)

a. 1-cornea
2 – pupil
3 – iris
4 – lens
5- retina
6 – ciliary muscle
7 – optic nerve

3 marks

b. Light enters through the cornea which bends the light rays so they pass through the pupil. The iris controls how much light enters the eye. Rays then come to a sharp focus on the retina which changes the rays into light pulse on the nerve endings sending information through the optic nerve.



3 marks

Question 7 (5 marks)

a. Short sighted – myopic

1 mark

b. $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$u = \infty$

$\frac{1}{f} = \frac{1}{\infty} + \frac{1}{210}$

$f = -2.1$ m

2 marks

c. $Power = \frac{1}{focal\ length} = \frac{1}{-2.1} = -0.48$ diopter

2 marks

Question 8 (4 marks)

a. A cataract is the clouding of the eye's natural lens which leads to a defect in vision. If the lens is clouded and not clear the image received by the retina will not be sharp hence causing blurred vision

2 marks

b. Cataract blindness may be corrected in minor cases by glasses. Where the lens is significantly clouded it can be removed by surgery and replaced with an artificial lens.

2 marks

Section C: Options

Option 10: How do instruments make music?

Question 1

Answer: B

Explanation: Sound travels as a series of compressions and rarefractions where the particles move backwards and forwards as the sound moves along. This is an example of a longitudinal wave.

Question 2

Answer: B

Explanation: $L = 10 \log_{10} \frac{I}{I_o}$

$76 = 10 \log_{10} \frac{I}{1 \times 10^{-12}}$

$I = 4.0 \times 10^{-5}\ \text{W m}^{-2}$

$\frac{I_1}{I_2} = (\frac{d_2}{d_1})^2$

$\frac{4.0 \times 10^{-5}}{I_2} = \left(\frac{2}{10}\right)^2$

$I_2 = 1.0 \times 10^{-3}\ \text{Wm}^{-2}$

dB = 90 dB

Question 3

Answer: D

Explanation: $f_n = \frac{nv}{4L}$

$f_5 = \frac{5 \times 340}{4 \times 0.5}$

$f_5 = 850$ Hz

Question 4

Answer: C

Explanation: Lucas hears the sounds differently due to diffraction. Low frequency sounds diffract whereas high frequency sounds are much more directional. Lucas will therefore hear the tuba as a louder sound compared to the trombone.

Question 5

Answer: C

Explanation: When reading the graph the following information can be obtained:

300 Hz at 65 dB would have an apparent intensity of 60 phon
50 Hz at at 70 dB has an apparent intensity of above 50 phon but below 60 phon
100 Hz at 70 dB has the same apparent intensity of 60 phon
3000 Hz at 63 dB has an apparent intensity of 70 phon – it is louder
20 Hz at 80 dB has an apparent intensity of 50 phon

Therefore C would appear louder

Question 6 (6 marks)

a. Standing waves are a vibrational pattern within a medium where the vibrational frequency of a source causes reflected waves to interfere with incident waves
This occurs in such a way that specific points undergo destructive interference as they are out of phase and others undergo constructive interference as they are in phase. This causes the wave to appear as if it is standing still

2 marks

b. $f_n = \frac{nv}{2L}$
$250 = \frac{1\times400}{2\times L}$
$L = 0.8$ m

2 marks

c. $f_5 = 5f_1$
$f_5 = 5 \times 250 = 1250$ Hz

2 marks

Question 7 (6 marks)

a. $f_n = \frac{nv}{4L}$

$f_1 = \frac{1 \times 340}{4 \times 0.8}$

$f_1 = 425 \text{ Hz}$

2 marks

b. $f_3 = 3f_1$
$f_3 = 3 \times 425$
$f_3 = 1275 \text{ Hz}$

$f_5 = 5f_1$
$f_5 = 5 \times 425$
$f_5 = 2125 \text{ Hz}$

2 marks

c. When a wave hits a closed end it will not undergo a change in phase.
Therefore a pressure antinode will always occurs at a closed end
Only odd harmonics can be formed

2 marks

Question 8 (3 marks)

Using Pythagoras the distance from speaker A to the student is:

$\sqrt{10^2 + 3^2} = 10.44$

Path difference for sound travel = $10.44 - 10 = 0.44$ m

Wavelength of the sound
$v = f\lambda$
$340 = 386 \times \lambda$
$\lambda = 0.88$ m

$pd = \left(n - \frac{1}{2}\right)\lambda$

Path difference equals half a wavelength hence the student is standing on a nodal point hence the sound will be soft to no sound.

Section C: Options

Option 11: How can performance in ball sports be improved?

Question 1

Answer: C

Explanation: $\rho = mv$

$\rho = 0.14 \times 8.5 = 1.19$ kg m s^{-1}east

Question 2

Answer: B

Explanation: $\rho = mv$

$\rho = 0.14 \times 6.5 = 0.91$ kg m s^{-1}west

Question 3

Answer: D

Explanation: Final total momentum = initial total momentum

Taking east as positive
$\rho_f = 1.19 - 0.91 = 0.28$ kg m s^{-1} east
As one ball has stopped rolling the moving ball has all the momentum
$0.14v_f = 0.28$
$v_f = 2$ m s^{-1} east

Question 4

Answer: A

Explanation: Air on bottom of the ball is travelling faster therefore there is lower pressure. The air on the top of the ball is travelling slower hence there is higher pressure. Hence a downwards force is created.

Question 5

Answer: A

Explanation: $v = \omega r$

$v = 8 \times 0.105 = 0.84 \text{ m s}^{-1}$

Question 6 (9 marks)

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

$v^2 = 0 + 2 \times 9.8 \times 15$

$v = 17.14 \text{ m s}^{-1}$

2 marks

b. $e = \sqrt{\frac{rebound\ height}{drop\ height}}$

$0.85 = \sqrt{\frac{rebound\ height}{15}}$

$rebound\ height = 10.84 \text{ m}$

2 marks

c. $e = \frac{speed\ seperation}{speed\ approach}$

$0.85 = \frac{speed\ seperation}{17.14}$

$speed\ seperation = 14.57 \text{ m s}^{-1}$

2 marks

d. $e = \sqrt{\frac{rebound\ height}{drop\ height}}$

$0.85 = \sqrt{\frac{rebound\ height}{10.84}}$

Height = 7.83 m hence will only clear 8 m on the first bounce

3 marks

Question 7 (6 marks)

a. $F_k = \mu N$

$F_k = 0.45 \times 150 = 67.5$ N

2 marks

b. $t = \frac{2u}{7\mu g}$

$t = \frac{2 \times 2.75}{7 \times 0.45 \times 9.8}$

$t = 0.62$ s

2 marks

c. $v = \frac{5u}{7}$

$v = \frac{5 \times 2.75}{7}$

$v = 1.96\ m\ s^{-1}$

2 marks

Section C: Options

Option 12: How does the human body use electricity

Question 1

Answer: C

Explanation: When firing occurs in the neuron there is an action potential created by a depolarizing current

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Question 2

Answer: D

Explanation: Currents below 100 mA will cause muscle contractions and pain, a current of 0.2A will cause the heart to fibrillate hence potentially fatal

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Question 3

Answer: C

Explanation: Hyperpolarisation is the change in a cells membrane potential that makes it more negative, inhibiting action potentials.

Question 4

Answer: C

Explanation: Referring to the graph, time constant is 63% of full charge ($15 \times 0.63 = 9.45$ V). This occurs at 1 sec.

Question 5

Answer: C

Explanation: $\tau = RC$
$1 = R \times 100 \times 10^{-6}$
$R = 10000$
$R = 10\ \text{k}\Omega$

Question 6 (7 marks)

a. The action potential starts in the SA node above the right atrium. Once depolarised this propagates through the atria which stimulate AV node. The AV node stimulates "fibres of His" which divides further into Purkinje fibres that stimulate the ventricle walls. The signals stimulate the contraction of the right and left atrium followed by the right and left ventricle.

2 marks

b. ECG (electrocardiogram) measures the electrical activity of the heart by placing a series of electrodes on the skin. Its function is to measure the strength and timing of the electrical signals travelling from the SA node to the AV node hence recording the rate and rhythm of heartbeat. It does this by measuring the change in potential difference as action potential progress through the heart. As depolarisation works its way through from the atria to the ventricles different signals are picked up by the ECG

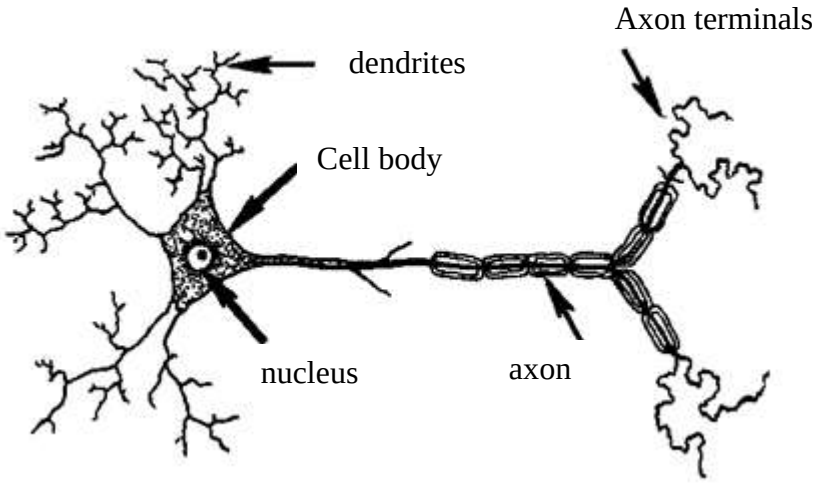
2 marks

c. P = atrial depolarisation
QRS = ventricular depolarisation
T = ventricular repolarisation

3 marks

Question 7 (8 marks)

a.



2 marks

b. Neurons are found within the nervous system

1 mark

c. Electrical signal transmitted along the axon as an action potential. This cause cell to become depolarised then polarised allowing the flow of ions of sodium, potassium. Concentrations of Na^+ on the outside of the cell and K^+ on the inside diffuse through ion channels causing cell to change from being polarised to depolarised back to polarised as charge is sent through.

2 marks

d. Sensory neuron – responds to sensations such as taste and touch
Motor neuron - responds to brain stimuli by transmitting signals along nerve cell body to muscle cells
Interneurons – handle communication between other two neurons

3 marks