PHYSICS

Unit 2– Written examination

2019 Trial Examination

SOLUTIONS

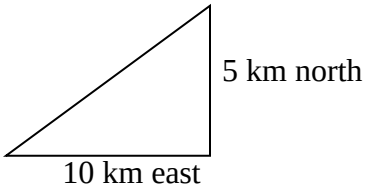
SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: D

Explanation:

The overall perpendicular components of Lachlan's motion are shown below.



Using Pythagoras' theorem the resultant displacement is found as:

$\sqrt{10^2 + 5^2} = 11.18$ km

The angle is equal to $90 - (\tan^{-1}\frac{5}{10}) = 63.43°$

Question 2

Answer: D

Explanation:

The maximum acceleration or deceleration is the gradient of the steepest section of the graph. This occurs between a time of 10 and 12 seconds where the acceleration is equal to 1.5 m s^{-2}.

Question 3

Answer: A

Explanation:

The area above the line can be found by $\left(\frac{1}{2}\times 5\times 4+\frac{1}{2}\times 3\times 1+3\times 4+\frac{1}{2}\times 4\times 3\right)=29.5$ and the area below the line is equal to $\left(\frac{1}{2}\times 2\times 3+3\times 3+\frac{1}{2}\times 3\times 5\right)=19.5$

The net displacement is the difference between these two values. Hence is 10 m

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Question 4

Answer: B

Explanation:

Time for the ball to go up can be found via:

$v=u+at$
$0=10+(-9.8)t$
$t=1.02$ s

Hence at 1.5 seconds the ball is travelling down with a velocity equal to:

$v=u+at$
$v=0+9.8\times 0.48=4.7$ m s^{-1}

Question 5

Answer: D

Explanation:

$60 \div 3.6 = 16.67$ m s^{-1}
$80 \div 3.6 = 22.22$ m s^{-1}
Conservation of momentum in a locked collision:
$m_1u_1 \pm m_2u_2 = (m_1 + m_2)v$
$400 \times 16.67 - 600 \times 22.2 = (400 + 600)v$ (taking right as positive)
$v = -6.65 = 6.65$ m s^{-1} left

Question 6

Answer: A

Explanation:
Impulse = change in momentum

$Ft = m\Delta v$
$F \times 0.05 = 0.06 \times 8 \uparrow -0.06 \times 10 \downarrow$
$F = 21.6$ N up

Question 7

Answer: C

Explanation:

$F = ma$

$30 = (4 + 2)a$
$a = 5$ m s^{-2}

$F_{B\ on\ A} = 30 - 4 \times 5 = 10$

Question 8

Answer: D

Explanation:

As the block is not moving the net force acting on the block must be 0. Therefore there must be a frictional force equivalent to the applied force balancing out the net force and hence no acceleration.

Question 9

Answer: B

Explanation:

$\sum F = W + N$

$\sum F = 50 \times 9.8 \downarrow + 60.2 \times 9.8 \uparrow$
$\sum F = 99.96$ N upwards

$99.96 = 50 \times a$
$a = 2$ m s^{-2}

Question 10

Answer: B

Explanation:

$W = Fd \cos\theta$

$W = 15 \times 20 \cos 30 = 259.8$ J

Question 11

Answer: C

Explanation:

Averaging out the recorded values

$$\frac{24.51 + 24.55 + 24.50 + 24.49 + 24.48}{5} = 24.506$$

Total uncertainty is equivalent to the difference between the highest and lowest number hence:
$24.55 - 24.48 = 0.07$

As the smallest measurement on a ruler is 0.1 cm, the final result should be written as
24.5 ± 0.07 cm

Question 12

Answer: D

Explanation:

$W = \sum F$

$mg = kx$
$2 \times 9.8 = k \times 0.245$
$k = 80$ N m^{-1}

Question 13

Answer: A

Explanation:

The acceleration is the dependent variable for an independent variable of mass and constant variable of force.

Question 14

Answer: B

Explanation:

Precision describes how close two or more measurements are to each other and accuracy describes how close the measurements are to theoretical values.

Question 15

Answer: C

Explanation:

100 is initially recorded as 1 significant figure which means the answer must also be recorded as 1 significant figure.

Multiply $9.8 \times 100 = 980$ therefore the answer must be rounded up to1000.

SECTION B: Short-answer questions

Question 1 (4 marks)

a. 35 km h^{-1} $= \frac{35}{3.6} = 9.72$ m s^{-1}

$s = \frac{(u+v)t}{2}$

$s = \frac{(0+9.72)30}{2} = 146$ m

2 marks

b. $v = u + at$

$9.72 = 0 + a \times 30$

$a = 0.32$ m s^{-2}

2 marks

Question 2 (10 marks)

a. Impulse equal area under a force vs. time graph

$Area = \frac{1}{2} \times 14 \times 0.3 = 2.1$ Ns

2 marks

b. $I = \Delta p$

$2.1 = 0.058 \Delta v$

$v = 36.21$ m s^{-1}

2 marks

c. Horizontal

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

$24 = 36.21 \times t + \frac{1}{2} \times 0 \times t^2$

$t = 0.663$ s

Vertical

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

$s = 0 \times 0.663 + \frac{1}{2} \times 9.8 \times 0.663^2$

$s = 2.15$ m

3 marks

d. Horizontal velocity $v = 36.21$ m s^{-1}

Vertical velocity

$v = u + at = 0 + 9.8 \times 0.663 = 6.497$ m s^{-1}

Resultant velocity

$v = \sqrt{36.21^2 + 6.497^2} = 36.8$ m s^{-1}

3 marks

Question 3 (6 marks)

a. Taking torques about pillar B.

$F_A \times d = F_{beam} \times d + F_{person} \times d$

$F_A \times 1 = 25 \times 9.8 \times 1 + 45 \times 9.8 \times 3$

$F_A = 1568$ N down

3 marks

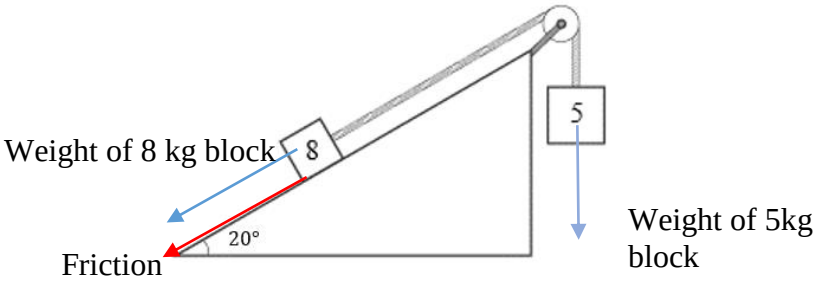
b. Forces up = forces down

$F_B = 1568 + 25 \times 9.8 + 45 \times 9.8 = 2254$ N up

3 marks

Question 4 (7 marks)

a.



Weight of 5kg block = 1 mark

Weight of 8 kg block down the incline and friction = 1 mark

2 marks

b. $W = mg = 5 \times 9.8 = 49$ N

2 marks

c. $\sum F = ma$
$49 - (8 \times 9.8 \sin 20 + 10) = (5 + 8)a$
$a = 0.94$ m s^{-2}

3 marks

Question 5 (5 marks)

a. $\sum F =$ Driving force – friction $= ma$
But if velocity is constant the acceleration is zero.
$\sum F = 0$
Driving force therefore equals friction.
$D.F = 1000 + 2500 = 3500$ N

2 marks

b. Tension – friction on object being towed $= ma$
$T = 1500 \times 1.5 + 2500 = 4750$ N

3 marks

Question 6 (7 marks)

a. Assume energy is conserved, but converted from gravitational potential to kinetic energy as the ball falls.

Total energy at 2 m high
$mgh = 1.5 \times 9.8 \times 2 = 29.4$ J
Total energy at 0.5m high
$mgh + \frac{1}{2}mv^2$
$1.5 \times 9.8 \times 0.5 + \frac{1}{2} \times 1.5 \times v^2 = 29.4$
$v = 5.42$ m s^{-1}

2 marks

b. At 0.2 m high, with the spring compressed 0.3 m, we have elastic potential energy, a small amount of gravitational potential energy and no kinetic energy. The total energy remains 29.4 J.
$29.4 = 1.5 \times 9.8 \times 0.2 + \frac{1}{2} \times k \times 0.3^2$
$k = 588$ N m^{-1}

2 marks

c. $\Delta E = mg\Delta h = 1.5 \times 9.8 \times 1 = 14.7$ J
Energy could be converted to heat, sound, permanent deformation of the spring.

3 marks

Question 7 (3 marks)

$m_1u_1 \pm m_2u_2 = (m_1 + m_2)v$
$0.6 \times 2 - 0.75 \times 1 = (0.6 + 0.75)v$
$v = 0.33$ m s^{-1}

E_k before the collision $= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 = \frac{1}{2} \times 0.6 \times 2^2 + \frac{1}{2} \times 0.75 \times 1^2 = 1.58$ J

E_k after the collision $= \frac{1}{2}mv^2 = \frac{1}{2} \times 1.35 \times 0.33^2 = 0.07$ J

E_k before $> E_k$ after, hence the collision is inelastic.

Question 8 (14 marks)

a. The aim of this experiment is to use a freefall machine to drop a small metal ball from a variety of different heights in order to calculate the acceleration due to gravity, by measuring the time taken.

2 marks

b. Independent variable is height
Dependent variable is time
Control variable is the ball

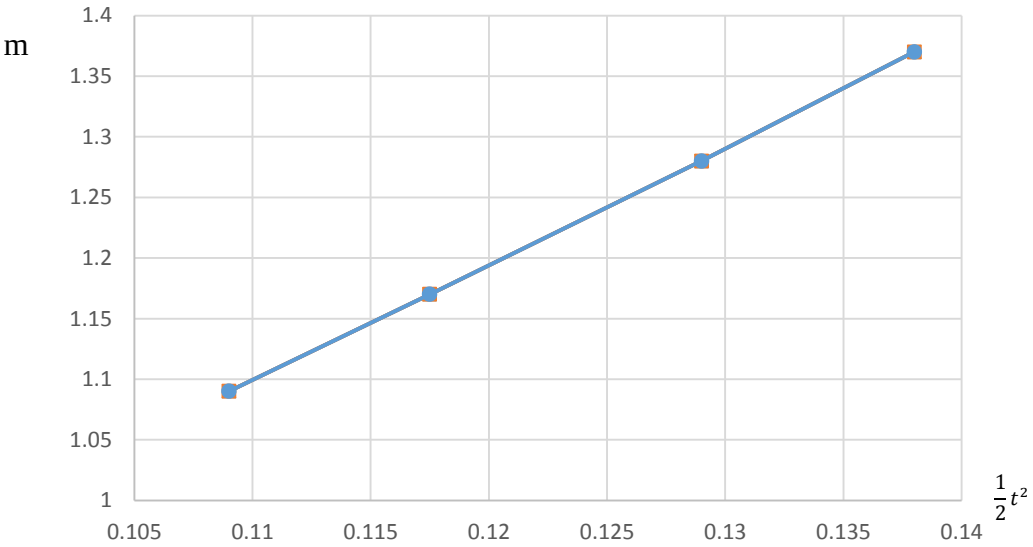
3 marks

c. $s = ut + \frac{1}{2}at^2$
As the initial velocity is 0
$s = \frac{1}{2}at^2$

By plotting $s\ vs\ \frac{1}{2}t^2$ the gradient is the graph is equal to the acceleration.

2 marks

d.



$gradient = \frac{rise}{run} = \frac{1.36-1.09}{0.138-0.109} = 9.31\ \text{m s}^{-2}$

3 marks

e. $\%\ difference = \frac{actual\ value - calculated\ value}{actual\ value} \times 100\%$
$= \frac{9.8 - 9.31}{9.8} \times 100 = 5\%$

2 marks

f. Error in timing – random error
Error in timing mechanism – systematic error
Incorrect measurement – random error

2 marks

Section C: Options

Option 2.1: What are stars?

Question 1

Answer: B

Explanation:

Stars give off energy due to the fusion process where two hydrogens are fused to form deuterium which fuses with another hydrogen to form helium which then fuses with another helium – this is called a proton-proton cycle. Bigger stars can also use the carbon cycle where protons fuse using carbon as a catalyst.

Question 2

Answer: C

Explanation:

The hottest stars are blue-white in their colour. As the star gets hotter the radiation emitted changes wavelength moving towards the ultraviolet end of the spectrum.

Question 3

Answer: B

Explanation:

If our Sun is relatively stable, then the gravitational force and the radiation pressure are approximately equal; consequently the size of the Sun is relatively constant.

Question 4

Answer: A

Explanation:

Hertzsrpung-Russell diagram displays the luminosity of a star vs its surface temperature.

Question 5

Answer: C

Explanation:

When our sun dies it will become a White Dwarf.

Question 6 (9 marks)

a. Gravitational force

1 mark

b. In main sequence, stars nuclear fusion is occurring. The gravitational force still exists pulling stars atoms inwards. Radiation (which is a result of the high temperatures produced during nuclear fusion) is pushing atoms away from the centre keeping the forces balanced.

2 marks

3

i. White dwarf –The star has exhausted its nuclear fuel causing the core collapses into dense white dwarf.

2 marks

ii. Black Hole – The nuclear fusion process has ended in a massive star. The gravitational force causes the centre of the star to collapse onto itself and the outer layers are blasted into space. The centre becomes so dense that the gravitational force does not allow radiation to escape. 2 marks

c. Nuclear fusion nuclei are forced together or fused - converts hydrogen into helium. In larger stars fusion causes helium to form carbon and oxygen, this can cause a chain reaction to produce elements from silicon to iron.

2 marks

Question 7 (6 marks)

a. Stars in the upper left corner of a HR diagram have high luminosity. They are also hot and blue in colour.

2 marks

b. Stars in the upper right are Supergiants. They have high luminosity but lower temperatures.

2 marks

c. Betelgeuse is an enormous red supergiant. Due to its huge surface area the total amount of radiation it emits is very large so it appears bright in our sky.

2 marks

Section C: Options

Option 2.2: Is there life beyond our solar system?

Question 1

Answer: C

Explanation:

In order for a planet to be habitable there must be liquid water on its surface.

Question 2

Answer: B

Explanation:

The red shift of light is from galaxies moving away from us, it has a lower frequency and a longer wavelength.

Question 3

Answer: A

Explanation:

Hubble's Law states that $v = H_0 r$ where v= recessional velocity, H_0 is a constant and r is the distance.

Question 4

Answer: D

Explanation:

A binary star in which shifting lines in the spectrum indicate orbital revolution hence radial velocity.

Question 5

Answer: C

Explanation:

SETI is carried out using radio telescopes in the search for radio signals.

Question 6 (10 marks)

a. Light from hot objects produces a continuous spectrum. When light passes through a cloud of gases it will absorb certain wavelengths leaving black bands. Therefore due to the lines that are present it tells us what elements are present in the gas.

2 marks

b. The surface temperature is calculated from the wavelength of the maximum emission from the star. The rotational velocity is determined from the Doppler shifts in the absorption lines in the spectrum.

2 marks

c. When the star is moving away from the observer there is a perceived increase in the wavelength of the light reaching the observer - Doppler Effect. This causes a change in the spectra of the light produced to move towards the red end of the spectrum. If the star is moving towards Earth there is a perceived decrease in the wavelength hence the spectra of light is shifted towards the blue end of the spectrum.

2 marks

d. In this case, there is a decrease in Vega's wavelength therefore the spectra is shifted to the blue end and the star is moving towards Earth.

2 marks

e. $v = \frac{\Delta\lambda}{\lambda} \times c$

$v = \frac{0.03}{656.285} \times 3 \times 10^8 = 13713.55 \text{ m s}^{-1}$

2 marks

Question 7 (5 marks)

a. Planets are relatively small, they lie close to their parent star and shine by light reflected off that parent star.

2 marks

b. Wobble - The effects of a planets gravitational pull on a parent star will cause the parent star to have a slight wobble
Doppler Effect - A massive planet and star will revolve around their centre of mass, as the star moves alternating away and then towards us its light will appear blue and red shifted.

3 marks

Section C: Options

Option 2.3: How do forces act on the human body?

Question 1

Answer: D

Explanation:

Tendons are the strongest of the soft tissues however bones are stronger still.

Question 2

Answer: A

Explanation:

By raising your arms above your head you now have more mass above the current centre of mass, hence the new centre of mass will be higher.

Question 3

Answer: C

Explanation:

$$strain = \frac{\Delta l}{l}$$
$$strain = \frac{7.5}{162} \times 100\% = 4.6\ \%$$

Question 4

Answer: A

Explanation:

In the human body first class levers are rare – one example is the joint between the head and the first vertebrae. Most levers in the human body are third class.

Question 5

Answer: D

Explanation:

When implanting into the human body the difficulties encountered include immune system resistance, the individual needs to get used to it and it needs to be custom made.

Question 6 (6 marks)

a. The elbow is an example of a third class lever. The effort in a third class lever is the in middle and lies between the fulcrum which is the elbow and the load which is the arm and the ball. Within this system the biceps provide the effort to stabilise the load which is the ball and the arm.

3 marks

b. $F_B d = F_{arm} d + F_{mass}\, d$
$F_B \times 0.045 = 1.5 \times 9.8 \times 0.20 + 4 \times 9.8 \times 0.31$
$F_B = 336$ N

3 marks

Question 7 (3 marks)

A tendon is strong as the relatively high elastic limit, as shown on the graph, shows it is able to withstand significant tension and return to its original condition without damage after the tension is removed. The large plastic region shows it is tough because even though it may suffer some damage, it can absorb a large amount of energy (as shown by the area under the graph in this region) before finally breaking.

Question 8 (3 marks)

$$Stress = \frac{Force}{Area}$$

$Ft = m\Delta v$
$F \times 4 \times 10^{-3} = 3 \times 20.83$
$F = 15622.5$ N
$Stress = \frac{15622.5}{0.00025} = 6.3 \times 10^{7}$Pa
Hence unlikely to withstand the force.

Question 9 (3 marks)

Carbon fibre is strong like bone to withstand large amounts of force and polyethylene reduces wear and lasts for large periods of time.

Material suitable for bone to grow into implant.

Section C: Options

Option 2.4: How can AC electricity charge a DC device?

Question 1

Answer: C

Explanation:

63% reduction is equal to 4.4 V hence a time constant of 40 ms.

Question 2

Answer: C

Explanation:

$\tau = RC$
$40 \times 10^{-3} = 200 \times C$
$C = 200\ \mu F$

Question 3

Answer: C

Explanation:

A full wave bridge rectifier has 4 diodes.

Question 4

Answer: B

Explanation:

Ratio for the numbers of turns to voltage is $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

Therefore increasing the numbers of turns in the secondary side increases the output voltage.

Question 5

Answer: C

Explanation:

Light travels down the fibre optic due to Total Internal Reflection at the core cladding boundary.

Question 6 (3 marks)

$P = VI$
$300 \times 10^{-3} = 2 \times I$
$I = 0.15$ A
$V = IR$
$V_R = 11 - 2 = 9$
$9 = 0.15 \times R$
$R = 60\ \Omega$

Question 7 (6 marks)

a. $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$\frac{V_p}{V_S} = \frac{100 \times \sqrt{2}}{8}$

$\frac{V_p}{V_s} = \frac{141.42}{8}$

$\frac{V_p}{V_2} = \frac{17.68}{1}$

2 marks

b. $V_s = 8 - 2 \times 0.6$
$V_s = 6.80\text{V}$

2 marks

c. $V = IR$
$6.80 = I \times 400$
$I = 17\text{ mA}$

2 marks

Question 8 (6 marks)

a. Output voltage is the reverse bias voltage of the Zener diode hence 6V

2 marks

b. Input voltage is 9V hence $V_R = 9 - 6 = 3\text{ V}$

2 marks

c. With no load the current in the diode is the same as the current through the resistor.
$V = IR$
$3 = I \times 100$
$I = 30\text{ mA}$

Section C: Options

Option 2.5: How do heavy things fly?

Question 1

Answer: A

Explanation:

The role of the propeller in an aircraft is to drive a stream of air backwards and this causes a reaction force which pushes the propeller forwards.

Question 2

Answer: A

Explanation:

Bernoulli's equation can be used to explain lift on an airplane wing.

Question 3

Answer: D

Explanation:

A streamlines surface that provides aerodynamic forces when interacting with a moving stream of air are called an aerofoil.

Question 4

Answer: D

Explanation:

Lift must exceed the weight force in order to take off given the aircraft is rising.
$Weight = mg = 3 \times 10^6 \times 9.8 = 2.94 \times 10^7$ N hence D is the best option.

Question 5

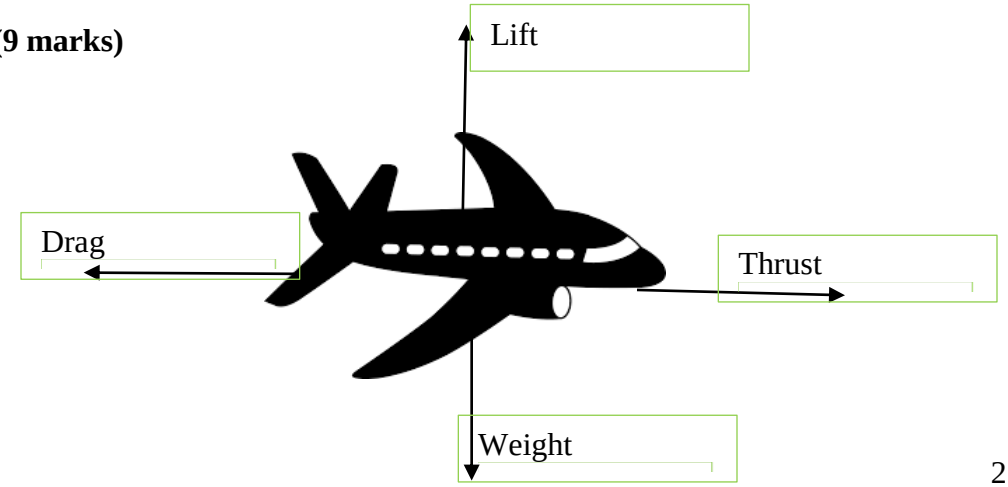
Answer: A

Explanation:

Thrust must exceed drag therefore the only drag lower than 4.68×10^5 N is
3.6×10^5 N

Question 6 (9 marks)

a.



2 marks

b. Newton's 1st law is that every object persists in a state of rest of uniform motion unless compelled to change by an external force
Within flight there are four major forces acting on an aircraft; lift, weight, thrust, and drag. A plane travelling a constant velocity in a straight line has no net force. If the thrust is changed the acceleration and lift of a plane can alter.
Newton's 3rd law – for every action there is an equal but opposite reaction. Thrust of engines pushes air back reaction force pushing plane forward. Movement of the air over the wings pushes the air down reaction force is lift on wings.

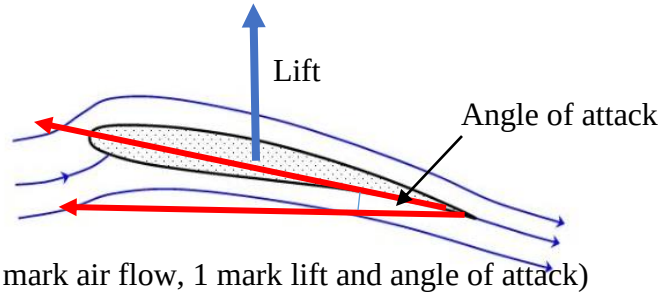
4 marks

c. Induced drag
Due to the 3D nature of the wing, the wing creates a different air pressure between the lower and upper surface which creates a vortex at the rear of the wing. Vortex creates a lift force that also acts to oppose the forward motion
Parasitic Drag
Skin Friction – caused by contact between the air and the surface of plane – worse when surface dirty
Form Drag – due to shape of the surface – has improved with increased aerodynamic principles

3 marks

Question 7 (6 marks)

a.



(1 mark air flow, 1 mark lift and 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 –the difference in 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

Section C: Options

Option 2.6: How do fusion and fission compare as viable energy power sources?

Question 1

Answer: D

Explanation: A fissile material is one that is capable of sustaining a chain reaction.

Question 2

Answer: B

Explanation: $\mathbf{{}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{236}_{92}U \rightarrow {}^{144}_{x}Cs + {}^{90}_{37}Rb + 2\ {}^{1}_{0}n}$

Using the above reaction the sum of the atomic numbers within the reactants is 92 hence the products also needs to add to 92 therefore $x = 92 - 37 = 55$.

Question 3

Answer: D

Explanation:

In order for two small nuclei to fuse they initially must have enough energy to overcome the repulsion force which will then allow the strong nuclear force bring them together.

Question 4

Answer: A

Explanation:

Nuclear fusion is the process in which two lighter nuclei join together to form a larger, more stable nucleus.

Question 5

Answer: C

Explanation:

The amount of the critical element within the fuel rod required to sustain a chain reaction.

Question 6 (6 marks)

a. Fission reaction.

2 marks

b. One neutron causes a uranium atom to split releasing other neutrons. In a controlled reaction one of these released neutrons will then combine with another atom and the process continues (the rest of the released neutrons would be absorbed by the control rods within a reactor).

2 marks

c. In an uncontrolled chain reaction, more than one of the released neutrons is available to combine with other uranium atoms. It means that the amount of energy that is released is significantly higher possibly causing an explosion.

2 marks

Question 7 (9 marks)

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

4 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.

2 marks

c. Unlimited supply of energy without contributing to global warming.
Don't produce hazardous materials as a by-product on a significant scale.
Easier to stop than fission as no chain reaction occurs.

3 marks

Section C: Options

Option 2.7: How is radiation used to maintain human health?

Question 1

Answer: D

Explanation:

An MRI has the ability to produce a cross sectional image of the body without moving the patient. It uses the body's magnetic properties to produce detailed images that can be built up to form a cross sectional image

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Question 2

Answer: D

Explanation:

If the doctor needs 4 grams and the tracer has a half-life of 4 hours it will undergo 3 decays during the travel time. Hence $4 \times 2^3 = 32$ grams will need to be produced by the manufacturer.

Question 3

Answer: B

Explanation:

To calculate dose equivalent the absorbed dose is multiplied by the type of radiation the tissue is exposed too.

Question 4

Answer: A

Explanation:

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

Question 5

Answer: B

Explanation:

When positrons and electrons annihilated they are transformed into energy in the form of gamma radiation.

Question 6 (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. X-ray passes through the body and some of the energy of the X-ray beam are absorbed. X-rays that aren't absorbed pass through the item being X-rayed, and they hit a photographic plate to give an image.

2 marks

c. X-rays are good at showing up bones due to their high density but soft tissue allows the X-ray beam to pass through it. This is due to attenuation. The amount of attenuation is due to the density of a material. Bone being dense has a high attenuation while soft tissue does not.

2 marks

d. Hard X-rays have a shorter wavelength. These are the most penetrating. They undergo very little absorption in materials. Hard X-rays are preferred for imaging as they penetrate the body and are absorbed by material such as bone, allowing images of bone to be observed. Long wavelength, low energy X-rays are called soft X-rays. They can be more easily absorbed by many materials Soft X-rays are not useful for imaging bones as they will not penetrate the body as they are absorbed by tissue within the body.

2 marks

e. Whereas a plain x-ray takes just one picture, during a CT scan many x-ray images can be taken of cross sections of our body. This allows doctors to visualise organs, bones and blood vessels hence allowing for more accurate information to be obtained. However, this exposes the human body to higher doses of radiation, which can be dangerous, particularly if they are used whenever possible as per the statement.

2 marks

Question 7 (5 marks)

a. $Absorbed\ dose = \frac{energy}{mass} = \frac{5\times10^{-3}}{60} = 8.3 \times 10^{-5}$

$Dose\ equivalent = absorbed\ dose\ \times quality\ factor = 8.3 \times 10^{-5} \times 1$

$Dose\ equivalent = 83$ μSv

2 marks

b. Stomach

$Effective\ Dose = Dose\ Equivalent\ \times weight = 8.3 \times 10^{-5} \times 0.12 = 10$ μ Sv

Thyroid

$= 1000 \times 10^{-6} \times 0.05 = 50$ μSv

Thyroid dose higher hence Patient B is at greater risk.

3 marks

Section C: Options

Option 2.8: How do particle accelerators work?

Question 1

Answer: C

Explanation:

Synchrotron radiation is produced when the electron beam is deflected through powerful magnets hence changing its direction.

Question 2

Answer: D

Explanation:

In a particle accelerator electric fields are used to accelerate the particles, the faster the particles the heavier they become and use of magnets controls the position of the particles hence all three statements are correct.

Question 3

Answer: C

Explanation:

The primary role of a particle accelerator is to make new particles and explore their behaviour.

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 used for the implanting ions in silicon chip, proton therapy in cancer treatment and the production of radioisotopes.

Question 6 (8 marks)

a. The proton synchrotron accelerates protons. The protons are accelerated up to 10 GeV of energy producing energy higher than that of electron.

2 marks

b. A cyclotron also accelerates positively charged particles. It is based on the principle of cross fields, that is, electric and magnetic field that are perpendicular to each other. When a positively charged particle is moved again and again in high-frequency electric fields and perpendicular magnetic fields the particles are accelerated to higher energy levels.

3 marks

c. Higgs Boson
Gauge bosons
Baryons
Mesons

3 marks

Question 7 (7 marks)

a. The LHC is the world's largest and most powerful particle accelerator. Developed to investigate the world's smallest particles. It simulates the conditions of the very early universe soon after the big bang.

2 marks

b. Two high-energy particle beams travel at close to the speed of light before they are made to collide. Magnets are used to direct the beams around the accelerator. Just prior to collision, another type of magnet is used to "squeeze" the particles closer together to increase the chances of collisions.

2 marks

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

3 marks

Section C: Options
Option 2.9: How can human vision be enhanced?

Question 1

Answer: A

Explanation:

The eye focuses on objects at different distances by changing the focal length of the eye lens. The range over which this works varies, this variation in the focal length of the eye-lens is called accommodation.

Question 2

Answer: B

Explanation:

Short-sightedness is due to the eye having a short focal length. A diverging lens can be used to correct this, therefore a concave lens.

Question 3

Answer: D

Explanation:

The lens in the human eye is biconvex in its nature allowing light to refract to the retina.

Question 4

Answer: A

Explanation:

Hypermetropia is long sightedness – hence convex lens.

Question 5

Answer: A

Explanation:

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

$$-\frac{1}{10} = \frac{1}{30} + \frac{1}{v}$$

$$v = -7.5cm$$

$$M = -\frac{v}{u} = -\frac{-7.5}{30} = 0.25$$

Question 6 (10 marks)

a. Hypermetropia – long sightedness. The lens in the eye is focusing the rays of light at a point behind the retina. To correct a converging lens is required.

3 marks

b. Myopia – short sightedness. The lens is focusing the rays of light in front of the retina. To correct a diverging lens is required.

3 marks

c. Light is not evenly focused on the retina resulting in distorted images, due to the lens being curved differently in different places. This problem is fixed via glasses or surgery.

2 marks

d. After the age of 40 presbyopia which is a condition that causes the lens to harden may occur. This condition is similar to hypermetropia where the rays of light focus behind the retina. Corrected by a converging lens.

2 marks

Question 7 (5 marks)

a. As the light rays from the fish leaves the water into the air is speeds up and refracts away from the normal. The person above sees an apparent position of the fish which is closer to the surface than the real position of the fish.

2 marks

b. $90 - 30 = 60°$
$n_i \sin\theta_i = n_r \sin\theta_r$
$1.0 \sin 60 = 1.33 \sin\theta_r$
$\theta_r = 40.63°$

3 marks

Section C: Options

Option 2.10: How do instruments make sound?

Question 1

Answer: D

Explanation

$v = f\lambda$
$f = \frac{500}{20} = 25$ Hz
$T = \frac{1}{f} = \frac{1}{25} = 0.04s$

Question 2

Answer: B

Explanation

Musical sounds tend not to be discussed in terms of wavelength. Pitch, quality and loudness are all regularly discussed as characteristics of musical sounds.

Question 3

Answer: C

Explanation:

The frequency determines the pitch. The higher the frequency, the higher the pitch

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Question 4

Answer: D

Explanation:

Within open and closed pipes the waves will reflect back up the pipe and interfere with the waves coming down. At resonant frequencies these waves will form standing waves.

Question 5

Answer: D

Explanation

5000 Hz at 40 dB appears to have a level of 50 phon.

Question 6 (11 marks)

a. Louder sounds occur when resonance occurs in the pipe. Resonance occurs when the wave being sent down the tube is of the right frequency to form a standing wave, with nodal and antinodal points, when it interferes with the sound being reflected back up the pipe from the other end. The amplitude of this standing wave is greater than the original wave and hence a significantly louder sound is produced.

2 marks

b. $f_1 = \frac{v}{2L} = \frac{340}{2\times0.55} = 309.1$ Hz

2 marks

c. $f_2 = 2f_1 = 2 \times 309.1 = 618.2$ Hz
$f_3 = 3f_1 = 3 \times 309.1 = 927.3$ Hz

2 marks

d. $f_1 = \frac{v}{4L} = \frac{340}{4\times0.55} = 154.5454$ Hz
$f_1 = \frac{v}{4L} = \frac{340}{4 \times 0.55} = 154.5$
$f_3 = 3f_1 = 3 \times 154.54 = 463.6$ Hz
$f_5 = 5f_1 = 5 \times 154.54 = 772.7$ Hz

3 marks

e. When the wave hits an open end it undergoes a change in phase due to a change in pressure, forming a nodal point at an open end. This results in all harmonics being formed.
At a closed end there no pressure change, hence no change in phase – an antinodal point forms therefore only odd harmonics

2 marks

Question 7 (4 marks)

a. The function of the ear drum is to transform the vibrations of the air particles in the outer ear (caused by the incoming sound) into tiny movements of the bones in the ossicles.

2 marks

b. The movements of the bones are transferred to vibrations in the fluid of the cochlea. The cochlea then transforms these vibrations into neural signals which then travel via the auditory nerve to the brain.

2 marks

Section C: Options

Option 2.11: How can performance in ball sports be improved?

Question 1

Answer: B

Explanation:

Terminal velocity refers to the object no longer accelerating hence it is moving with constant velocity.

Question 2

Answer: C

Explanation:

Terminal velocity; therefore upwards force equal to weight force $W = mg = 59 \times 9.8 = 578.2$ N

Question 3

Answer: D

Explanation:

$$e = \sqrt{\frac{rebound}{drop}}$$
$$rebound = drop \times e^2$$

$$rebound = 2 \times 0.7^2 = 0.98$$
$$rebound = 0.98 \times 0.7^2 = 0.48$$
$$rebound = 0.48 \times 0.7^2 = 0.24$$

Question 4

Answer: A

Explanation:

Find velocity just before first bounce

$v^2 = u^2 + 2as$
$v^2 = 0 + 2 \times 9.8 \times 2$
$v = 6.26 \text{ m s}^{-1}$

$e = \dfrac{v_{after}}{v_{before}}$
$v_{after} = e \times v_{before}$
$v_{after\,1} = 0.7 \times 6.26 = 4.38$
$v_{after\,2} = 0.7 \times 4.38 = 3.07$
$v_{after\,3} = 0.7 \times 3.07 = 2.15$

Question 5

Answer: A

Explanation: $\Delta v = v - u = \overrightarrow{15} - \overleftarrow{10} = 25 \text{ m s}^{-1}$ right

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Question 6 (10 marks)

a. $v^2 = u^2 + 2as$
$0 = (40 \sin 20)^2 + 2 \times -9.8 \times s$
$s = 9.55 \text{ m}$

2 marks

b. $v = u + at$
$0 = 40 \sin 20 + (-9.8)t$
$t = 1.4 \times 2 = 2.8\text{s}$

2 marks

c. $s = ut = 40 \cos 20 \times 2.8 = 105.25 \text{ m}$
$distance\ from\ hole = 110 - 105.25 = 4.75 \text{ m}$

3 marks

d. The backspin produces a higher air velocity above the ball and a lower air velocity below the ball. Due to the Bernoulli Principle these different velocities of the air produce a lower pressure above the ball compared with below the ball.
This causes a net upwards force or lift on the ball.

3 marks

Question 7 (5 marks)

a. $\alpha = \frac{\Delta\omega}{t} = \frac{34-36}{0.6}$
$\alpha = -3.33$ radians s^{-2}

2 marks

b. $\Delta\theta = \omega t + {}^{1}/_{2}\,\alpha t^2 = 36 \times 0.6 + {}^{1}/_{2} \times -3.33 \times 0.6^2 = 21$ radians
$21 \times \frac{1\ rev}{2\pi rad} = 3.34$ revolutions

3 marks

Section C: Options

Option 2.12: 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.

Question 2

Answer: C

Explanation: There are approximately 100 – 10 000 synapses in each neuron.

Question 3

Answer: C

Explanation:

Conduction within the heart involves the fibres of His propagating signals across the ventricles.

Question 4

Answer: C

Explanation:

A defibrillator delivers approx. 5 kV and up to 50 A through 2 paddles on the chest.

Question 5

Answer: A

Explanation:
An ECG (electrocardiogram) is the device used to measure the human heart beat.

Question 6 (6 marks)

a. Everything we do is controlled and enabled by electrical signals. Electrical signals in our brains are fast, they allow for nearly instantaneous responses to control messages.

2 marks

b. The brain generates an electrical signal and sends it out through the neurons. The signal travels through each neuron as an electrical signal then converts to the chemical signal to cross the synapse. Once it reaches the next neuron it converts back to an electrical signal until it reaches its destination.

2 marks

c. All cells are slightly negatively charged inside and positively charged outside creating a negative potential between the outside and the inside. Concentrations of Na^+ on the outside of the cell and K^+ on the inside diffuse through ion channels causing cells to change from being polarised to depolarised back to polarised as a voltage is sent through.

2 marks

Question 7 (6 marks)

a. $velocity = \frac{distance}{time} = \frac{7.2\times10^{-2}-3.4\times10^{-2}}{0.0063-0.0052} = 35 \text{ m s}^{-1}$

There are two measurements as there may be a time delay from the stimulation of the nerve to the action potential.

2 marks

b. Via the action potential. Initially the cell is at a resting potential with a slight negative charge. The cell becomes stimulated by a current of sodium ions which causes the cells to depolarise. As a result the cell now has a slight positive charge. As the sodium ions move in potassium ions move out – this reduces the excess of positive ions and repolarises the membrane.

2 marks

c. Some of the ions that flood into the membrane during depolarisation spread along the length of the axon, this stimulates an action potential in the next segment of the axon.

2 marks

Question 8 (3 marks)

Heart contains groups of cells within the sinoatrial node. These cells contain electrolytes of Na^+ and $K^{+.}$ In this case the Na^+ enters and K^+ leaves causing slight positive charge. An action potential is created when Ca^+ channels open and Ca^+ enters as well. This then discharges down the nerves in the heart.