PHYSICS

Unit 2 – Written examination

2021 Trial Examination

SOLUTIONS

SECTION A – CORE

Question 1 (1 mark)

Answer: C

Explanation:

$Speed = \frac{d}{t}$

$av.speed = \frac{800}{95}$

$= 8.42 \text{ m s}^{-1}$

Question 2 (1 mark)

Answer: D

Explanation:

$\frac{150}{3.6}$

$= 42 \text{ m s}^{-1}$

Question 3 (1 mark)

Answer: A

Explanation:

Use Pythagoras for displacement:
$s = \sqrt{3^2 + 4^2}$
$s = 5$ km
Resultant vector points N $\theta°$ E. Use trig to find angle from North.
$\cos\theta = \frac{4}{5}$
$\theta = 37°$

Question 4 (1 mark)

Answer: A

Explanation:

$$a = \frac{\Delta v}{t}$$

$$a = \frac{3.5 - 8.5}{2} = -2.5 \text{ m s}^{-2}$$

Question 5 (1 mark)

Answer: D

Explanation:
This requires knowledge of what is and what isn't a vector.

Question 6 (1 mark)

Answer: C

Explanation:

Newton pairs never act on the same body, so the normal force can't be the force pair to the weight force. A is just another way of describing a force.

Question 7 (1 mark)

Answer: C

Explanation:
The angle is adjacent to the horizontal, therefore $\cos\theta = \frac{F_h}{F}$ so then $F_h = F\cos\theta$

Question 8 (1 mark)

Answer: B

Explanation:
$I = \Delta p = m\ v_f - v_i\ = 0.1\ -2 - 8\ = -1$ kg m s^{-1}

Negative was taken to be to the left.

Question 9 (1 mark)

Answer: D

Explanation:
Definition of mass and weight

Question 10 (1 mark)

Answer: A

Explanation:

$F = k\Delta x$
$10 = k \times 0.02$
$k = 500$ N m^{-1}

Question 11 (1 mark)

Answer: B

Explanation:

Resolve the weight force into parallel and perpendicular components.
The parallel forces are unbalanced. Perpendicular forces are balanced.
Parallel component must be net force.
$F_{para} = mg\sin\theta$
$= 2 \times 9.8 \times \sin 35°$
$= 19.6 \times \sin 35°$

Question 12 (1 mark)

Answer: A

Explanation:
$W = Fs$
$W = 1200 \times 0.008$
$W = 9.6\ \text{J}$

Question 13 (1 mark)

Answer: C

Explanation:

See-saw is balanced, therefore the torques are balanced.
$\tau_{net} = (Fd)_{40} - \ Fd\ _{50}$
$0 = 40 \times 9.8 \times 2.5 - 50 \times 9.8 \times x$
$x = 2\ \text{m}$

Question 14 (1 mark)

Answer: C

Explanation:

Conducting multiple trials helps to reduce the spread of data, thus reducing the effect of random fluctuations. B and D will better your accuracy. A is just wrong.

Question 15 (1 mark)

Answer: D

Explanation:

The measurement goes from 1 cm to 8.5 cm. A difference of 7.5 cm.
The uncertainty is half the smallest division that is half of a mm, which is 0.05 cm.

SECTION B – CORE

Question 1 (15 marks)

a. Draw a straight line from (0,0) to (4,6). The gradient of this is the average acceleration:

$$gradient = \frac{6-0}{4-0} = \frac{6}{4} = 1.5 \text{ m s}^{-2}$$

1 mark

b. The gradient between (0,0) and (14,0) is just 0. So average acceleration is 0 m s^{-2}

1 mark

c. Gradient at 8 seconds is that same as the gradients between 7 seconds and 10 seconds.

$$gradient = \frac{-3-6}{10-7} = -\frac{9}{3} = -3 \text{ m s}^{-2}$$

1 marks

d. Find the area under graph. Students can use any combination of shapes to do this as long as it's correct.

Area under graph $= \frac{1}{2} \times 2 \times 2 + \frac{1}{2}\ 2 + 6\ \times 2 + 3 \times 6 + \frac{1}{2} \times 2 \times 6 = 34$ m

That man has travelled positive 34 m from the starting position

3 marks

e. Area under graph $= \frac{1}{2} \times 1 \times -3 + 2 \times -3 + \frac{1}{2} \times 2 \times -3 = -10.5$ m

The man has travelled + 34 m and then -10.5 m, so overall, $34 - 10.5 =$ 23.5 m

3 marks

f. Looking directly from the graph he has zero velocity at times: 0 sec, 9 sec and 14 sec.

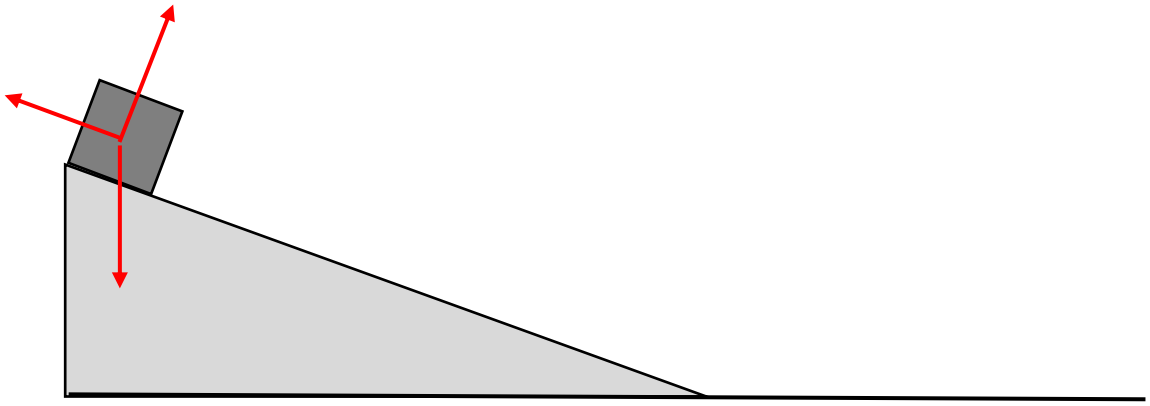
3 marks

g. When gradient is zero acceleration will be zero. Between 4 and 7 seconds and between 10 and 12 s

3 mark

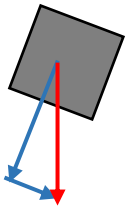
Question 2 (15 marks)

a.



3 marks

b. Students will need to resolve the weight force into parallel and perpendicular components



The box doesn't accelerate in the perpendicular axis. We are only concerned with the parallel vectors. Make down the plane positive.

$F_{net} = ma = mg \sin\theta - F_f$

$a = g \sin\theta - \frac{F_f}{m}$

3 marks

c. If the 5 kg box accelerates then we know that the heavier ones will also overcome the friction. Students will need to find the exact frictional force need to *just* stop the 5 kg from moving.

$F_{net} = ma = mg \sin\theta - F_f$

$0 = mg \sin\theta - F_f$

$mg \sin\theta = F_f$

$F_f = mg \sin\theta$

$F_f = 5 \times 9.8 \times \sin 20°$

$F_f = 16.8 \text{ N}$

3 marks

d. $a = g\sin\theta - \frac{F_f}{m}$

$a = 9.8 \times \sin 20 - \frac{33}{15} = 1.15 \text{ m s}^{-2}$

2 marks

e. Use SUVAT.

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

$v = \sqrt{2 \times 1.15 \times 17}$

$v = 6.25 \text{ m s}^{-1}$

(Allow consequential answer using correct working with incorrect answer from d)

2 marks

f. Work done is $W = \Delta E_k$

$\Delta E_k = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$\Delta E_k = \frac{1}{2} \times 15 \times 3^2 - \frac{1}{2} \times 15 \times 5^2$

$\Delta E_k = -120 \text{ J}$

The ground has done 120 J of work on the box.

2 marks

Question 3 (10 marks)

a. $\frac{2000}{3.6} = 556 \text{ m s}^{-1}$

1 mark

b. $p_i = 0 \text{ kg m s}^{-1}$

$p_f = 0 = 5000 \times v - 100 \times 555.56$

$v = \frac{100 \times 555.56}{5000}$

$v = 11.1 \text{ m s}^{-1}$ to the left

3 marks

c. $5000 \times 11.1 = 5.56 \times 10^4 \text{ kg m s}^{-1}$ to the left.

2 marks

d. $F_{av} = \frac{I}{t} = \frac{5.56 \times 10^4}{3.6} = 1.54 \times 10^4 \text{ N}$ to the left.

2 marks

e. 1.54×10^4 N to the right. This is due to Newton's 3rd law. Every action has an equal and opposite reaction. The force on the air by the plane and the force on the plane by the air are a reactionary force pair

2 marks

Question 4 (15 marks)

a. It is hypothesised that as the spring is extended more and more from its resting position, the force required to hold it will increase. (Some students could also say that the force linearly increases with extension.)

1 mark

b. Spring extension from resting position.

1 mark

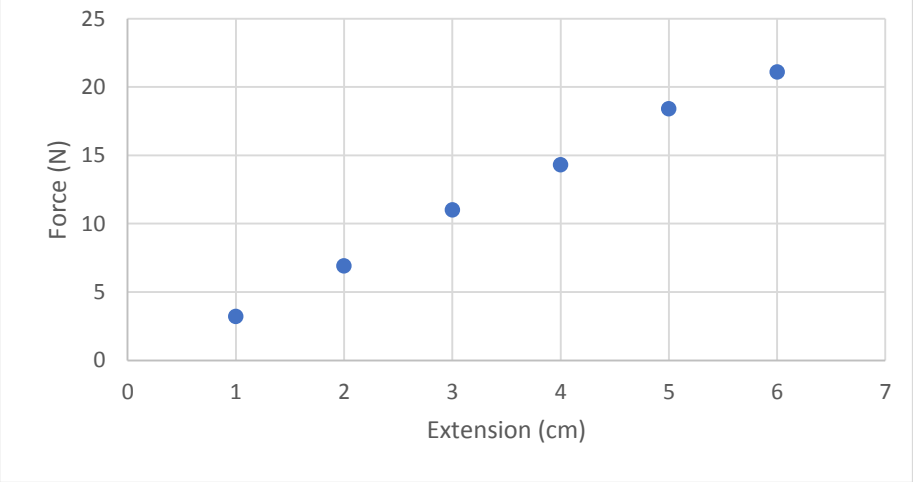
c. Force required.

1 mark

d. Using the same spring each trial. Keeping the temperature of spring relatively constant. Anything else that is appropriate.

1 mark

e. To get full marks students will need to include axes (1 mark), axes labels (1 mark), units (1 mark), appropriate scale on both axes (1 mark), all data points in the correct positions (2 marks). It should look something similar to this.



6 marks

f. Yes, it does. The plot is linear and cuts through the origin.

1 mark

g. Line of best fit.

1 mark

h. Use the line of best fit to determine gradient. Students will need to convert from cm to m first before finding gradient. Depending on the students' line of best fit, the gradient should be $m \approx 3.6$ N cm^{-1} or $m \approx 360$ N m^{-1}. Therefore $k \approx 360$ N m^{-1}

2 marks

OPTIONS

Option 2.1: What are stars?

Question 1 (1 mark)

Answer: B

Explanation:

Beta radiation is an electron or positron, which is matter, not EM radiation.

Question 2 (1 mark)

Answer: C

Explanation:

The other answers are other ways in which astronomers measure distances. This is just the definition of parallax

Question 3 (1 mark)

Answer: D

Explanation:
60 arc minutes per degree, 60 arc seconds per minute = 3600 arc sec / degree

Question 4 (1 mark)

Answer: A

Explanation:
Bluer stars are hotter. Also, relative magnitude depends on distance as well so it can't be C and D

Question 5 (1 mark)

Answer: A

Explanation:
Nuclear fusion is the fusion of hydrogen into helium. Stars are mainly made up of hydrogen.

Question 6 (6 marks)

a. $31 \text{ arc minutes} \times 60 \ \frac{\text{arc seconds}}{\text{arc minute}} = 1860 \text{ arc seconds}$

2 marks

b. **i.** $d = \frac{1}{p} = \frac{1}{0.38} = 2.63 \ pc$

ii. $2.63 \times 3.26 = 8.58 \text{ ly}$

4 marks

Question 7 (6 marks)

a. Standard Candle

1 mark

b. **i.** Orion nebula as it has the lowest apparent magnitude

1 mark

ii. $M = m + 5 - 5 \log d$

$15.6 = 11.1 + 5 - 5 \log d$

$\frac{15.6 - 11.1 - 5}{-5} = \log d$

$d = 1.26 = 1.3 \text{ pc}$

2 marks

iii. $M = m + 5 - 5 \log d$

$M = 4 + 5 - 5 \log 410$

$M = -4.06 = -4.1$

2 marks

Question 8 (3 marks)

a. A supernova is the only event with enough energy to turn a star into a black hole.

1 mark

b. $r_s = \frac{2GM}{c^2} = \frac{2 \times 6.7 \times 10^{-11} \times 100 \times 2.0 \times 10^{30}}{3.0 \times 10^{8\ 2}} = 3.0 \times 10^5 \text{ m}$

2 marks

Option 2.2: Is there life beyond the solar system?

Question 1 (1 mark)

Answer: C

Explanation:

Absorption spectra show the blacklines of absorbed wavelengths, whilst emission only show the wavelengths that are emitted.

Question 2 (1 mark)

Answer: C

Explanation:

An object moving towards you will have its wavelength bunch up. A shift towards a shorter wavelength is towards the blue end of the spectrum.

Question 3 (1 mark)

Answer: D

Explanation:
General knowledge.

Question 4 (1 mark)

Answer: D

Explanation:
The CHZ is only concerned with the range of distances from a star liquid water could exist.

Question 5 (1 mark)

Answer: D

Explanation:
Gravitational microlensing doesn't produce images of exoplanets, so B and C are out. A is just wrong as well. Microlensing uses the fact that the exoplanet will contribute to the lensing and distortions. If the star's properties are known we will be able to detect slight variances in these distortions as exoplanets.

Question 6 (4 marks)

a. This method requires the orbit of an exoplanet to travel across its parent star relative to our position on earth. As the planet moves across the star its brightness will diminish by some percentage. A periodic dip in the brightness of a star indicates a large object moving in front of the star

2 marks

b. The percentage of decrease can be related to how much area of a star's light the planet blocks, and hence the size of the planet can be determined.
The period dips in brightness can be used to determine the orbital period of the star.

2 marks

Question 7 (6 marks)

a. A star and its planet actually orbit around their combined centre of mass which will be close to the star's centre of mass. Therefore, the star will follow a circular path around this combined centre of mass which makes it look like the star is wobbling.

3 marks

b. **i.** The wavelength has increased by 0.2 nm. An increase in wavelength means a shift towards the red side of the spectrum. The wavelength is stretching out therefore the star is moving away.

1 mark

ii. $\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c} = \frac{0.2}{656} = \frac{v}{3.0\times10^8}$
$v = 9.15 \times 10^4$ m s^{-1}

2 marks

Question 8 (5 marks)

a. It is the supposed contradiction between the lack evidence for extra-terrestrial civilisations and the estimated probability that we should see them.

2 marks

b. Many answers could be acceptable:

- Extra-terrestrial civilisations are short-lived.
- Extra-terrestrial civilisations are rare.
- There is some great filter that stops most civilisations from becoming technologically advanced.

1 mark

c. Multiply all the variables together:
$N = 1 \times 0.5 \times 2 \times 1 \times 0.5 \times 0.1 \times 10000 = 500$ civilisations

2 marks

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

Question 1 (1 mark)

Answer: B

Explanation:

The two forces are the weight force and normal force. Both force act in opposite directions and towards each other.

Question 2 (1 mark)

Answer: D

Explanation:

Find centre of mass with 5kg object as reference point:

$$x_{cm} = \frac{0 + 2 \times 20 + 4 \times 50}{5 + 2 + 4} = 21.8 \text{ cm}$$

This is 21.8 cm from the 5 kg object. It is also true that the centre of mass is 1.8 cm to the right of the 2 kg object.

Question 3 (1 mark)

Answer: D

Explanation:
Whilst you could possibly get more torque having the bicep connect near the hand, this wouldn't be a practical solution as you would lose range of motion. Furthermore, you would have 0 torque if it was connected at the elbow joint. So D is the solution.

Question 4 (1 mark)

Answer: C

Explanation:

It represents a class 3 lever where the effort is between the fulcrum and the load.

Question 5 (1 mark)

Answer: A

Explanation:
Find the cross-sectional area, then find stress.
$A = \pi r^2 = \pi \times \ 0.002\ ^2$
$\sigma = \frac{F}{A} = \frac{\quad 2}{\pi \times \ 0.002\ ^2} = 1.59 \times 10^5 \text{ N m}^{-2}$

Question 6 (15 marks)

a. The tendon should be labelled **effort** and the weight force labelled **load**.

2 mark

b. Taking the ball of the foot as the pivot.

$$\tau = 550 \times .18 - F_T \times .23$$

$$F_T = 550 \times \frac{0.18}{0.23} = 430 \text{ N}$$

3 marks

c. $\sigma = \frac{F}{A} = \frac{430}{\pi \times \ 0.015\ ^2} = 6.01 \times 10^5 \text{ N m}^{-2}$

2 marks

d. No. $110 \text{ MPa} = 110 \times 10^6 \text{ N m}^{-2}$

1 mark

e. **i.** $\epsilon = \frac{\Delta L}{L} = \frac{25.5-25}{25} = 0.02 = 2\%$

2 marks

ii. $E = \frac{stress}{strain} = \frac{14 \times 10^6}{0.02} = 7.0 \times 10^8 \text{ Pa} = 700 \text{ MPa}$

2 marks

f. Looking at the graph the point of failure is at approximately 11% or 0.11.

1 mark

g. The plastic region is where the graph stops being linear. So, at about 8.8% the tendon is in the plastic region. This is the region where the material becomes permanently stretched/deformed. This would result in serious injury.

2 marks

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

Question 1 (1 mark)

Answer: B

Explanation:

Read directly from graph. Look at the largest voltage value.

Question 2 (1 mark)

Answer: A

Explanation:
Read directly of graph. Period is the time it takes to complete a full cycle, which is between 0.016 s and 0.017 s.

Question 3 (1 mark)

Answer: B

Explanation:

$$f = \frac{1}{T} = \frac{1}{0.017} = 60 \text{ Hz}$$

Question 4 (1 mark)

Answer: B

Explanation:
Knowing the properties of a Zener diode. These diodes act differently to normal diodes. The fact they can sustain constant voltages in reverse bias is what makes them useful.

Question 5 (1 mark)

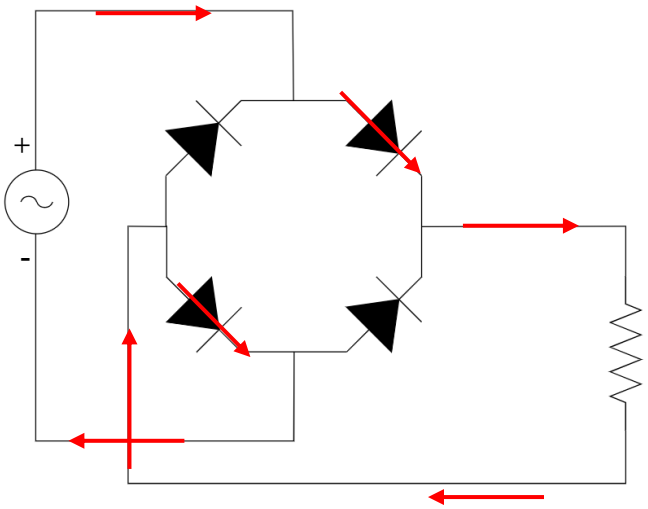
Answer: D

Explanation:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{120}{5} = \frac{24}{1}$$

Question 6 (9 marks)

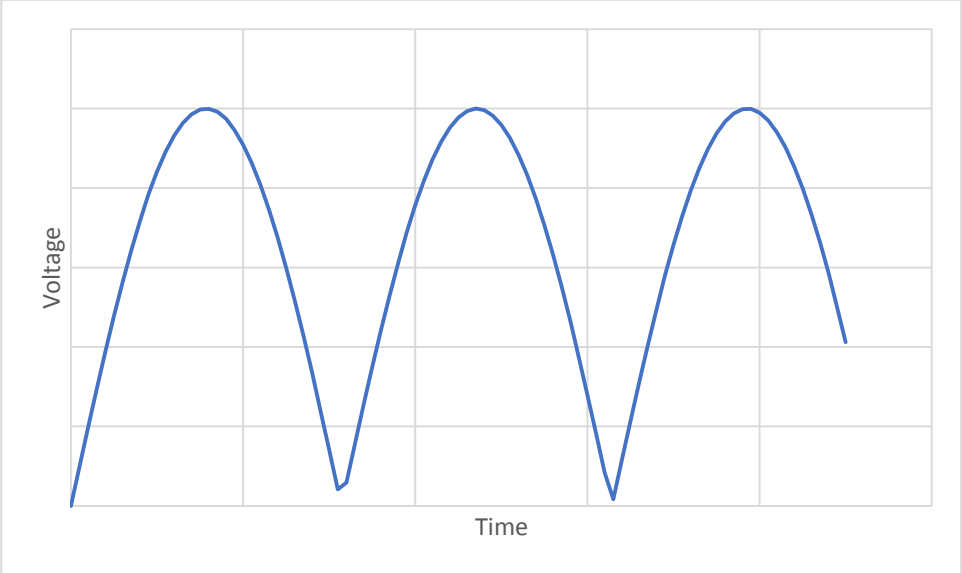
a.



The current shouldn't flow through two of the diodes. It should always flow away from the + terminal.

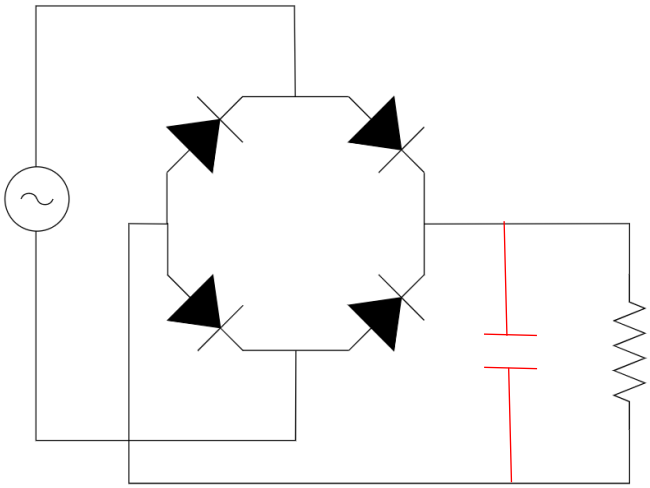
1 mark

b. The diodes turn all negative voltage into positive. So, the graph should look like this:
1 mark for sin wave shape, 1 mark for making everything positive.



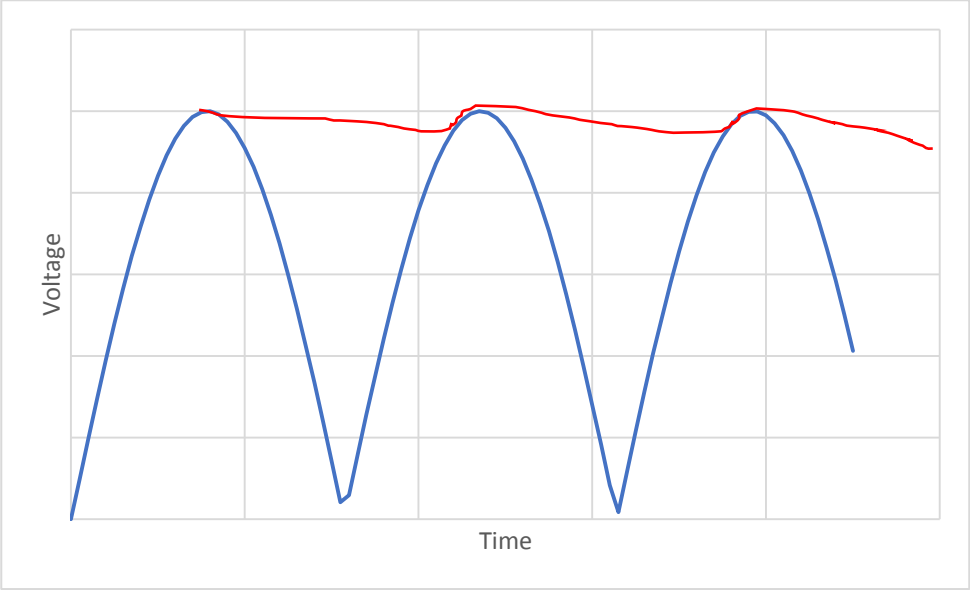
2 marks

c. The capacitor should run parallel with the resistor. 1 mark for correct placement, 1 mark for correct symbol



2 marks

d. Blue graph shows original. Red line shows smoothing.



2 marks

e. $\tau = RC = 1.1 \times 10^{-3} \times 15 \times 10^{3} = 16.5 \text{ s}$

2 marks

Question 7 (6 marks)

a. At 50° the variable resistor is 20 kΩ. Total resistance is $R_T = 20 + 5 = 25$ kΩ
$V = IR$
$10 = I \times 25 \times 10^3$
$I = 4.0 \times 10^{-4}$ A

2 marks

b. Voltage across the 5 kΩ resistor is:
$V = IR$
$V = 4.0 \times 10^{-4} \times 5 \times 10^3 = 2$ V

2 marks

c. There are many options here. Anything that depends on temperature:
Heater, toaster, kettle, fridge, etc.

2 marks

Option 2.5: How do heavy things fly?

Question 1 (1 mark)

Answer: D

Explanation:

$F = mg = 40 \times 10^3 \times 9.8 = 3.9 \times 10^5$ N.

Question 2 (1 mark)

Answer: B

Explanation:

Pitch is when an aircraft rotates it nose up or down

Question 3 (1 mark)

Answer: B

Explanation:
This is the definition of form drag. The other answers are other types of friction/drag.

Question 4 (1 mark)

Answer: B

Explanation:
Lift is an upwards force. The weight force always acts downwards, so they oppose each other.

Question 5 (1 mark)

Answer: D

Explanation:

As water is incompressible the velocity MUST increase in a smaller section of pipe to allow the same volume of water to flow. According to Bernoulli's principle the pressure must decrease in sections of high velocity.

Question 6 (7 marks)

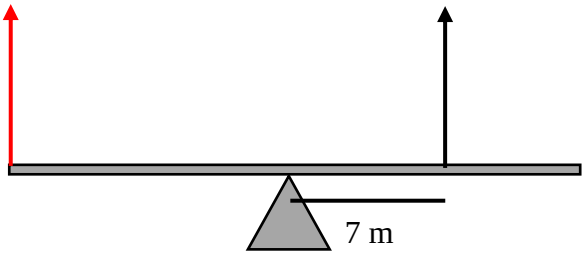


Figure 1

a. 1 mark for correct placement, 1 mark direction

2 marks

b. $\frac{24}{2} = 12$ m

1 mark

c. $\tau = 0$ if plane is balanced.

$$\tau = 0 = 5.2 \times 10^3 \times 7 - F_A \times 12$$

$$\frac{5.2 \times 10^3 \times 7}{12} = F_A$$

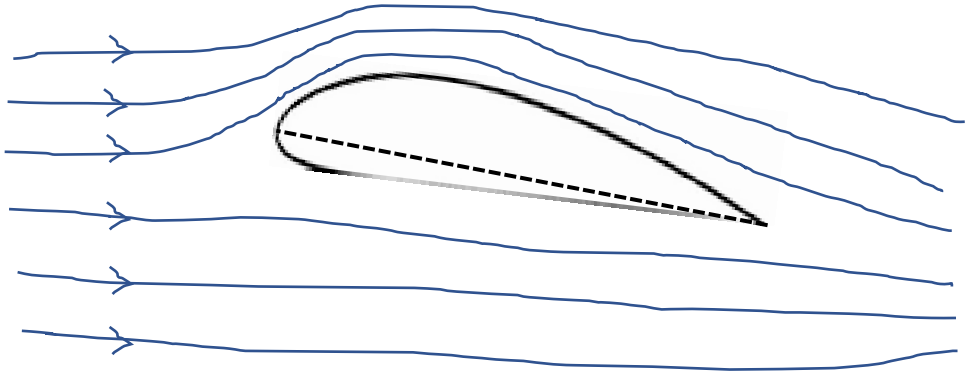
$$F_A = 3.0 \times 10^3 \text{ N}$$

2 marks

d. According to Newton's third law, for every action there is an equal and opposite reaction. For a plane to create thrust it must push off something. In the case of a plane it pushes air backwards at a high velocity using a propeller or turbine, so that it can push the plane forwards.

2 marks

Question 7 (8 marks)



a. 1 mark for above streamlines crowding together. 1 mark for below streamlines staying relatively constant distance apart.

2 marks

b. Air can be modelled as fluid flow around an object. As the streams above the airfoil come in contact with the airfoil they crowd together and increase their velocity due to having to travel a long distance around the airfoil, This means that there is a lower pressure at the top. Vice versa for the bottom, lower velocity, therefore higher pressure. The difference in pressure means that there is an overall upwards force on the wing which will hence be lifted up.

3 marks

c. The angle of attack is the angle between the airfoil (dotted line) and the wind velocity.

1 mark

d. As long as the angle of attack is sufficient that the streamlines above the wing have a longer distance to travel, then you will still achieve lift according to Bernoulli's principle. The upside-down airplane wouldn't be as efficient at producing lift due to the asymmetric nature of the airfoil.

2 marks

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

Question 1 (1 mark)

Answer: B

Explanation:

Charged particles are easily deflected by nuclei. Mass doesn't play much role in this process. So it must be B.

Question 2 (1 mark)

Answer: C

Explanation:

High velocity neutrons are not as easily absorbed by uranium-235. A moderator acts to slow neutrons down without absorbing them.

Question 3 (1 mark)

Answer: A

Explanation:
This isotope, when bombarded with neutrons, because highly unstable and fissions into two lighter elements and neutrons so the next reaction to occur.

Question 4 (1 mark)

Answer: D

Explanation:
Deuterium is very abundant in water, whilst tritium isn't.

Question 5 (1 mark)

Answer: D

Explanation:
The small mass loss between the reactants and the products is what produces the energy in a fusion reaction. The products MUST have less total mass than the reactants.

Question 6 (6 marks)

a. Y = 54, X = Xe

2 marks

b. The neutrons released during fission are fast moving and uranium-235 nuclei do not readily absorb the fast moving neutrons.

1 mark

c. The shape of the rods, the purity (concentration of uranium-235 atoms) and the mass of the nuclear material.

3 marks

Question 7 (3 marks)

a. X = Np , Y = Pu

2 marks

b. The plutonium that is created is also a good fuel for a fission reactor.

1 mark

Question 8 (6 marks)

a. X = neutron

1 mark

b. The energy of the reaction is transformed into kinetic energy of the products particles and into the gamma radiation.

2 marks

c. The energy released is proportional to the mass deficit according to $E = mc^2$

$$\frac{3.27 \times 10^6}{6.24 \times 10^{18}} = 5.24 \times 10^{-13} \text{ J}$$

$$m = \frac{E}{c^2} = \frac{5.24 \times 10^{-13}}{3.0 \times 10^{8\ 2}} = 5.82 \times 10^{-30} \text{ kg}$$

3 marks

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

Question 1 (1 mark)

Answer: D

Explanation:

All of the mentioned are radiation, but only gamma rays have enough energy to ionize molecules.

Question 2 (1 mark)

Answer: C

Explanation:

Whilst PET scans use radioactive materials that produce positrons, the positrons don't have the penetrating power to pass through the body. Instead, they excite the atoms around them, and gamma rays are produced.

Question 3 (1 mark)

Answer: B

Explanation:
This can be deduced by making sure the left and right sides of the equation add up. Remembering neutrons add 1 atomic weight and 0 atomic number. Beta minus particle emission adds 0 atomic weight and 1 atomic number (as a neutron decays to a proton and an emitted electron).

Question 4 (1 mark)

Answer: D

Explanation:
$DE = AD \times Q$
$10 = AD \times 20$
$AD = 0.5 = \frac{energy\ absorbed}{mass\ of\ tissue} = \frac{energy\ absorbed}{0.025}$
$\text{energy absorbed} = 0.5 \times 0.025 = 0.013\ \text{J}$

Question 5 (1 mark)

Answer: A

Explanation:
$\text{Eff. dose} = 20 \times 10^{-3} \times 0.05 + 20 \times 10^{-3} \times 0.12 + 15 \times 10^{-3} \times 0.05 = 4.2 \times 10^{-3}\ \text{Sv}$

Question 6 (5 marks)

a. Magnetic Resonance Imaging

1 mark

b. A very strong magnetic field is created around the human body. The magnetic field forces some protons to line up with this field. A low energy pulse of radio frequency radiation forces some of the protons to resonate and absorb energy. When the pulse stops the protons release the absorbed energy as detectable radiation, which is used to image the patient.

3 marks

c. It doesn't use ionising radiation.

1 mark

Question 7 (4 marks)

a. $X = \beta^-$

1 mark

b. Radiation can be both the cause and treatment of cancerous tumours. If phosphorus-32 builds up near the site of a tumour it will release beta radiation. This radiation doesn't penetrate very far so the tumour would absorb a high portion of it. This type of radiation can be used to destroy cancerous cells, thereby treating the patient.

2 marks

c. It is a radioisotope that is attached to other molecules or drugs.

1 mark

Question 8 (6 marks)

a. They have a higher energy and thus a stronger ionising radiation.

1 mark

b. X-rays have a QF of 1.

$$DE = AD \times QF$$

$$DE = \frac{56}{0.1} \times 1 = 560 \text{ Sv}$$

2 marks

c. A high voltage is created across a cathode and anode. The cathode is heated so that it releases electrons. The electrons are accelerated across the voltage towards the anode. As the electrons hit the anode they decelerate and emit X-ray radiation.

3 marks

Option 2.8: How do particle accelerators work?

Question 1 (1 mark)

Answer: A

Explanation:

Voltages and EM radiation interact with charged particles so that they can accelerate. This not the case for neutral particles. Massless particles already travel at the speed of light, hence D is also incorrect.

Question 2 (1 mark)

Answer: D

Explanation:

The gun accelerates them by strong voltages. After they leave the gun special cavities of high frequency radio waves accelerate the electrons by allowing them to "ride" on the travelling peaks of the wave.

Question 3 (1 mark)

Answer: B

Explanation:
A cyclotron doesn't synchronously increase the magnetic field to keep the particles on a circular path, hence why they spiral outwards in a cyclotron.

Question 4 (1 mark)

Answer: D

Explanation:
From 80 eV to 14 TeV there is a factor of 100 billion.

Question 5 (1 mark)

Answer: A

Explanation:
$$\frac{3 \times 10^{9}}{6.24 \times 10^{18}} = 4.8 \times 10^{-10}\ \text{J}$$

Question 6 (6 marks)

a. 100 kV gives 100 keV of energy to one electron.

$$\frac{100 \times 10^3}{6.24 \times 10^{18}} = 1.6 \times 10^{-14}\text{J}$$

Or $100 \times 10^3 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-14}\text{J}$

2 marks

b. Some magnets are used to direct the stream of electrons around the circular ring. Other magnets are used to focus the stream of electrons so that they don't diverge.

2 marks

c. At certain points along the storage ring magnets are used to redirect the electrons. If the velocity of the electrons is changed this means that they have been accelerated. Accelerated charges produce synchrotron light.

2 marks

Question 7 (6 marks)

a. To collide high speed charged particles together.

1 mark

b. The proton is the most commonly accelerated particle. They are prepared by taking hydrogen and stripping it of electrons to create protons.

2 marks

c. Any 3 of the following:
CMS
ATLAS
ALICE
LHCb

3 marks

Question 8 (3 marks)

Any three reasonable answerswill suffice here:

Cancer treatment

Carbon dating

Pharmaceutical research

Lithography

Imaging

Material composition of old artifacts.

Option 2.9: How can human vision be enhanced?

Question 1 (1 mark)

Answer: B

Explanation:

Diffraction occurs when light spreads out from an opening. In this case we have refraction. The light moves from a low to a high refractive index, therefore it was slow down and bend towards the normal.

Question 2 (1 mark)

Answer: C

Explanation:

This is just the definition of a virtual image.

Question 3 (1 mark)

Answer: D

Explanation:
Add the focal lengths to get the length of telescope. $100 + 3.5 = 103.5$ cm

Question 4 (1 mark)

Answer: A

Explanation:
Angle of incidence is always equal to angle of reflection.

Question 5 (1 mark)

Answer: A

Explanation:
The eye is similar to a pin hole camera. The image will be inverted.

Question 6 (6 marks)

a. **i.** In front of the retina

1 mark

ii. Behind the retina

1 mark

b. A lens for short sightedness needs to be a concave lens that will diverge parallel rays from distant objects before they reach the eye. The lens in the eye will then converge the rays further from the lens and thus on the retina.
A lens for long sightedness needs to be a convex lens that will converge rays from close objects before they reach the eye. The lens in the eye will then converge the rays closer to the lens and thus on the retina.

4 marks

Question 7 (7 marks)

a. Focal length is defined as the distance from the lens to the point at which parallel rays focus. So, 15 cm is the focal length of the lens.

1 mark

b. Yes.

1 mark

c. The right side of the lens

1 mark

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

$\frac{1}{25}+\frac{1}{v}=\frac{1}{15}$

$\frac{1}{15}-\frac{1}{25}=\frac{1}{v}$

$\frac{2}{75}=v$

$v = 37.5$ cm

2 marks

e. $M=-\frac{v}{u}=-1.5$

2 marks

Question 8 (2 marks)

$M=\frac{f_{obj}}{f_{eye}}=\frac{150}{2}=75$

Option 2.10: How do instruments make music?

Question 1 (1 mark)

Answer: B

Explanation:

General knowledge

Question 2 (1 mark)

Answer: A

Explanation:
$v = \lambda f$
$330 = \lambda \times 200$
$\lambda = 1.65$ m

Question 3 (1 mark)

Answer: A

Explanation:
Length, material and speed of sound in object all dictate the resonant frequency. The height will only change the amplitude of the wave not the frequency.

Question 4 (1 mark)

Answer: C

Explanation:

$$T = \frac{1}{800} = 0.0013 \text{ s}$$

Question 5 (1 mark)

Answer: C

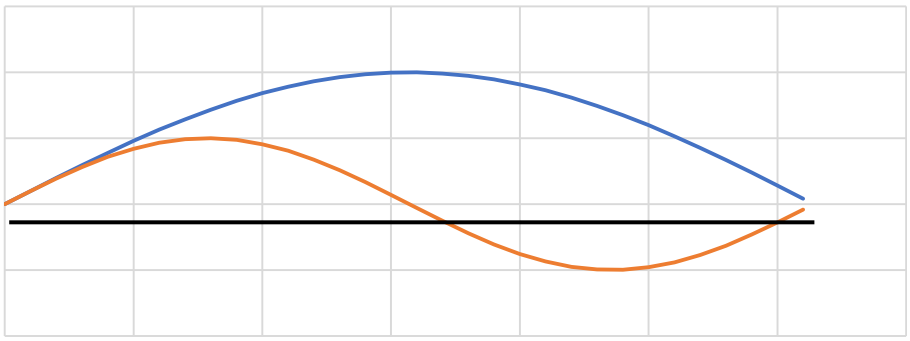
Explanation:
Two instruments could be playing the same note (pitch) but have different sounds. So A and D are out. B contradicts the question. It is the additional frequencies that the sound vibrates at that make the notes sound different.

Question 6 (7 marks)

a. Find wavelength:
$v = \lambda f$
$430 = \lambda \times 300$
$\lambda = 1.433$ m
The wavelength at the fundamental frequency for a wave with fixed ends is $\lambda = 2L$.
$L = \frac{1.433}{2} = 0.72$ m

3 marks

b. See blue line. It is also OK if students draw the negative of this graph, or even both with one being a dotted line.



1 mark

c. See orange line. The important idea is that it is double the frequency and clearly a smaller amplitude.

2 marks

d. $2 \times 300 = 600$ Hz

1 mark

Question 7 (6 marks)

a. $I = \frac{P}{4\pi r^2} = \frac{0.13}{4\times\pi\times1^2} = 1.0 \times 10^{-2}$ W m^{-2}

2 marks

b. $dB = 10 \log \frac{I}{10^{-12}} = 10 \log \frac{1.0\times10^{-2}}{10^{-12}} = 100$ dB

2 marks

c. $I = \frac{1.0\times10^{-2}}{100^2} = 1.0 \times 10^{-6}$

$$10 \log \frac{1.0 \times 10^{-6}}{10^{-12}} = 60$$

Students could also reason that the intensity drops off by a factor of 100^2 =10000, so the dB should drop by 40.

2 marks

Question 8 (2 marks)

As the machine oscillates the string up and down it sends pulses down the string. Those pulses bounce will bounce back off the pole. If the machine frequency matches the fundamental (or an integer multiple) the oppositely travelling waves will interfere to create a standing wave.

2 marks

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

Question 1 (1 mark)

Answer: C

Explanation:

$$e = \frac{h}{H} = \frac{1.2}{3} = 0.63$$

Question 2 (1 mark)

Answer: A

Explanation:

$$P_i = P_f$$
$$1.5 \times 9.0 + 1.2 \times 0 = 1.5 \times 5 + 1.2 \times v_{pin\ final}$$
$$\frac{1.5 \times 9.0 - 5.0 \times 1.5}{1.2} = v_{pin\ final} = +5.0 \text{ m s}^{-2}$$

Question 3 (1 mark)

Answer: C

Explanation:
A, B and D are true. There is zero horizontal net force, therefore no change in velocity.

Question 4 (1 mark)

Answer: D

Explanation:
If the ball is in contact AND it is rolling on the ground, the bottom edge of the ball must always be zero relative to the ground. This is counteracted by the top edge always being double the velocity.

Question 5 (1 mark)

Answer: A

Explanation:

$$\omega = \frac{v}{r}$$
$$25 = \frac{v}{0.05}$$
$$v = 1.3 \text{ m s}^{-1}$$

Question 6 (7 marks)

a. As the ball travels through the air the air gets trapped in the dimples. This trapped air now has a lower skin drag than if the ball had no dimples at all. Lower drag means the ball will travel further.

2 marks

b. $F_D = \frac{1}{2}\rho v^2 C_D A$

If all things are equal except for the velocity everything cancels so we get:

$$\frac{F_{D1}}{F_{D2}} = \frac{v_1^2}{V_2^2} = \frac{300^2}{100^2} = 9$$

2 marks

c. The direction of the streamlines are in the opposite direction as the velocity of the ball. The top part of the ball is moving in the same direction as the air and due to friction increase the velocity. On the bottom section the ball is moving against the streamline and hence slowing it down due to friction. Invoking Bernoulli's principle, the faster moving air below the ball will have a lower pressure, therefore the ball will experience an upwards force.

3 marks

Question 7 (8 marks)

a. Looking just at the vertical component (y) will determine flight time of ball. We can see how long it takes to reach the top of its flight.

$u_y = 15 \sin 35$

$a = -9.8 \text{ m s}^{-1}$

$v_y = 0 \text{ m s}^{-1}$

$t =?$

$v = u + at$

$0 = 15 \sin 35 + -9.8 \times t$

$$t = \frac{-15 \sin 35}{-9.8}$$

$t = 0.88 \text{ s}$

Multiply this by 2 to get the total flight time:

$t = 1.76 \text{ s}$

3 marks

b. Now we can look at the horizontal component. Acceleration is zero and horizontal velocity is constant, so we can just use:

$v = \frac{d}{t}$

$v_x = 15 \cos 35$

$t = 1.76 \text{ s}$

$d = 15 \cos 35 \times 1.76$

$d = 21.6 \text{ m}$

2 marks

c. $I = Ft => F = \frac{I}{t}$

The impulse is the change in momentum.

$F = \frac{15 \times 0.055 - 0 \times 0.055}{0.02}$

$F = 41.3 \text{ N}$

2 marks

d. This is Newton's third law. So, the force must be 41.3 N. Look specifically at magnitude, so direction doesn't matter here.

1 mark

Option 2.12: How does the human body use electricity?

Question 1 (1 mark)

Answer: A

Explanation:
It is in fact charged ions that carry signals throughout the human body.

Question 2 (1 mark)

Answer: C

Explanation:
The synapse is the region between the dendrite and axon that is responsible for communication between neurons.

Question 3 (1 mark)

Answer: D

Explanation:
When the post synaptic cell intakes positive ions this is known as depolarisation. Whilst hyperpolarisation would be the intake of negative ions.

Question 4 (1 mark)

Answer: A

Explanation:
If the heart kept contracting and relaxing with no delay between cycles, no blood would be able to be pushed around the body. This is what happens in cases of ventricular arrhythmias, where there is not enough oxygen-rich blood circulating around the body.

Question 5 (1 mark)

Answer: B

Explanation:
Defibrillation is the treatment for fibrillation. Fibrillation is an irregular heart rhythm.

Question 6 (7 marks)

a. $V = IR$

$I = \frac{V}{R} = \frac{240}{5000} = 0.048$ A

2 marks

b. $E = IVt = 0.048 \times 240 \times 0.5 = 5.76$ J

2 marks

c. Either severe shock OR muscle paralysis could be acceptable as the value 48 mA is between both.

1 mark

d. $I = \frac{V}{R} = \frac{240}{5000+100000} = 0.00228 \text{ A} = 2.28 \times 10^{-3} \text{ A}$

2 marks

Question 7 (6 marks)

a. Usually passing a current through the heart would be fatal, even 100 mA. When a patient is suffering from ventricular arrhythmia, they could be experiencing rapid heart beats without proper contractions (ventricular tachycardia) or they heart could be quivers ineffectively (ventricular fibrillation). In these states passing a current through the heart can depolarise the heart muscle and stop the irregular rhythm This then allows the heart's natural pacemaker, in the sinoatrial node, to restart the heart in its normal rhythm.

4 marks

b. $\tau = RC \Rightarrow C = \frac{\tau}{R} = \frac{15 \times 10^{-3}}{20 \times 10^{3}} = 7.5 \times 10^{-7} \, F = 0.75$ μF

2 marks

Question 8 (2 marks)

It stands for electrocardiogram. It measures the electrical activity of the heart. This can be used to detect abnormalities.