PHYSICS

Unit 2 – Written examination 2

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SOLUTIONS

SECTION A

Area of Study 1 – Motion

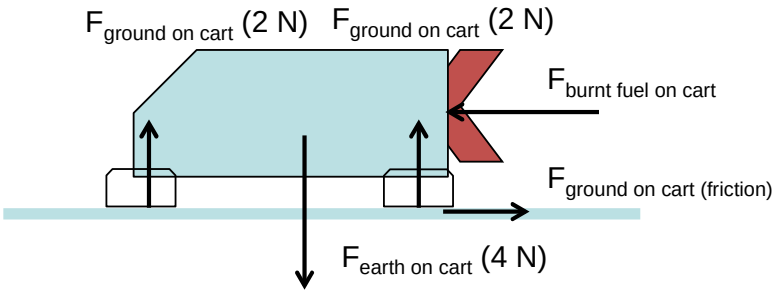
Question 1
Answer: **90 m South - Vector**
Explanation: Displacement is the area under the velocity-time graph. Positive displacement has a direction of South (as per graph). Displacement is a vector quantity.

Question 2
Answer: **7.5 m s^{-1} Scalar**
Explanation: Average speed = distance / time. Speed is a scalar quantity. Distance = displacement in this case as there is no change in direction of velocity.

Question 3
Answer: **100 N**
Explanation: As there is a drag force of 100 N and the bike is travelling at a constant velocity, according to Newton's First law there must be no net force so the driving force is 100 N.

Question 4
Answer: **5 m s^{-2} North**
Explanation: Acceleration is equal to the gradient of the velocity-time graph. Here, the gradient is equal to -10/2 = -5 m s^{-2}, or 5 m s^{-2} South.

Question 5
Answer: **See diagram**



Explanation: Weight force is calculated as 0.4 x 10 = 4 N. Reaction force is split between front and rear. Friction technically acts on both front and rear, but shown as 0.2 N total. Driving force is discussed further in Question 9.

Question 6
Explanation:
Aristotle would expect that the cart would move at a constant speed over the first 0.3 seconds, then gradually come to rest once the force was removed. In his theory of motion, objects required a constant force to continue motion.
Galileo recognised that the cart would accelerate due to the constant driving force over the first 0.3 seconds, then decelerate due to friction once the fuel was exhausted.

Question 7
Answer: **50 m s^{-2}**
Explanation: $a = \frac{\Delta v}{t} = \frac{15}{0.3} = 50\, m\, s^{-2}$

Question 8
Answer: **2.25 m**
Explanation: $s = 0.5 \times (u + v)t = 0.5 \times 15 \times 0.3 = 2.25 m$

Question 9
In a rocket engine the burned rocket fuel out of the back of the rocket. So, the rocket exerts a strong backward force on the burned rocket fuel. According to Newton's third law the required reaction is that the burned rocket fuel exerts an equal forward force on the rocket. This force accelerates the rocket forward.
Thus, $F_{\text{rocket on fuel}} = -F_{\text{fuel on rocket}}$

Question 10
Answer: **34.6 N**
Explanation: $F = F \cos 30 = 34.6 N$

Question 11
Answer: **24.6 N**
Explanation: $F_{Net} = F \cos 30 - 10 = 34.6 - 10 = 24.6 N$

Question 12
Answer: **4.9 m s^{-2}**
Explanation: $a = \frac{F_{Net}}{m} = \frac{24.6}{5} = 4.92 m s^{-2}$

Question 13
Answer: **173 J**
Explanation: $W = F \cos 30 \times 5 = 173 J$

Question 14
Answer: **123 J**
Explanation: $E_k = F_{Net} \times d = 24.6 \times 5 = 123 J$

Question 15

Answer: **53.7 W**

$$E_k = 123J = 0.5mv^2$$

$$v = \sqrt{\frac{2KE}{m}}\sqrt{\frac{2\times 123}{5}} = 7ms^{-1}$$

Explanation: $s = 0.5\times(u+v)t$

$$t = \frac{2s}{v} = \frac{2\times 8}{7} = 2.29\,\text{sec}$$

$$P = \frac{W}{t} = \frac{123}{2.29} = 53.7W$$

Question 16

Answer: **1.5×10^4 N m^{-1}**

Explanation: $k = \frac{F}{x} = \frac{450}{0.03} = 15000Nm^{-1}$

Question 17

Answer: **3.46 m s^{-1}**

Explanation: $v = \sqrt{\frac{2\Delta KE}{m}} = \sqrt{\frac{2\times 12.6}{2.1}} = 3.46ms^{-1}$

Increase in *KE* is equal to decrease in *PE = mgh.*

Question 18

Answer: **0.079 m**

$$EPE = 0.5k(\Delta x)^2$$

Explanation: $\Delta x = \sqrt{\frac{2\times EPE}{k}} = 0.041m$

$$\min length = 0.12 - 0.041 = 0.079m$$

SECTION A

Area of Study 2 – Wavelike Properties of Light

Question 1
Answer: **Wavelength = 0.8 m, Amplitude = 0.4 m**
Explanation: Wavelength is equal to the horizontal length for one full cycle. Amplitude is the distance from median value to the highest point.

Question 2
Answer: **2.2×10^{-3} s**
Explanation: Period = 1/frequency = 1/450 = 0.0022 s

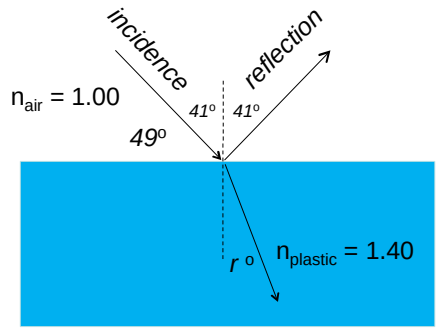
Question 3
Answer: **360 m s^{-1}**
Explanation: $v = f\lambda = 450 \times 0.8 = 360\, m s^{-1}$

Question 4
Answer: **Blue**
Explanation: Blue is generally accepted as wavelengths ranging from 400 – 490 nm.

Question 5
Answer: **2.03×10^{8} m s^{-1}**
Explanation: $v = \frac{c}{n} = \frac{3 \times 10^{8}}{1.48} = 2.03 \times 10^{8}\, m s^{-1}$

Question 6
Answer: **4.41×10^{14} Hz**
Explanation: $f = \frac{v}{\lambda} = \frac{2.03 \times 10^{8}}{460 \times 10^{-9}} = 4.41 \times 10^{14}\, Hz$

Question 7
Answer:



Explanation: Angles of incidence and reflection are equal and are measured from the ray to the normal (which is 90° to the boundary)

Question 8

Answer: **28°**

$$n_1 \sin i = n_2 \sin r$$

Explanation: $$r = \sin^{-1}\left(\frac{n_1}{n_2}\sin i\right)$$

$$r = \sin^{-1}\left(\frac{1}{1.4}\sin 41^o\right) = 27.9^o$$

Question 9

Answer: **42.2°**

$$i_{crit} = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

Explanation:

$$i_{crit} = \sin^{-1}\left(\frac{1}{1.49}\right) = 42.2^o$$

Question 10

Answer: **Angle will increase**

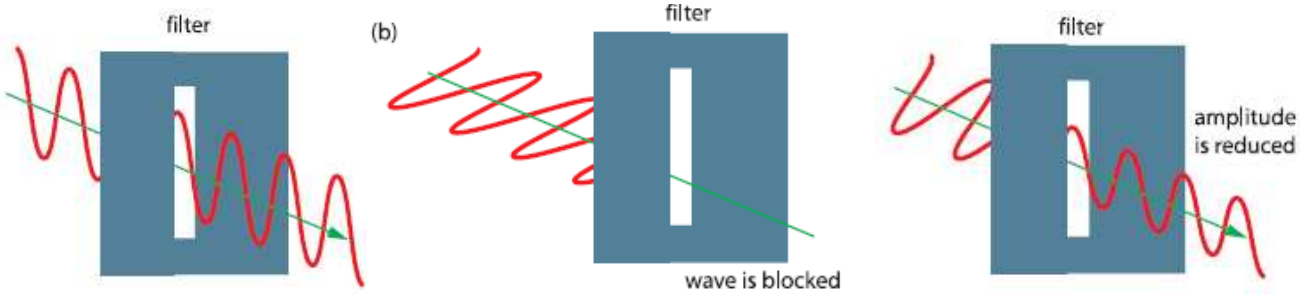
Explanation: Increasing the value of n_2 will lead to an increase in the critical angle, which means light must travel closer to parallel to the fibre to remain within it.

$$i_{crit} = \sin^{-1}\left(\frac{n_{water}}{n_1}\right)$$

$$i_{crit} = \sin^{-1}\left(\frac{1.33}{1.49}\right) = 63^o$$

Question 11

Explanation: Polarisation is a wavelike phenomena whereby transverse waves in certain planes are blocked by a filter, whilst others can pass. Referring to the diagram below, longitudinal waves (and particles) would transmit through both types of filters, but some transverse waves are blocked.

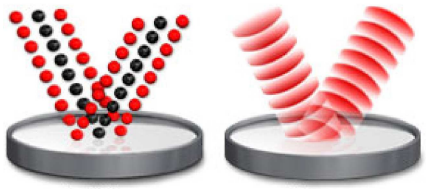


Vertically aligned light waves can pass unimpeded

Horizontally aligned light waves are blocked

Partially vert/horiz are reduced in intensity

Question 12
Any diagram should show the angle of incidence and angle of reflection as equal, for both waves and particles.



Particles Waves

Question 13
Medium 2 must have a higher refractive index, meaning light travels more slowly within it. For a given frequency (this remains constant) this would reduce the wavelength as shown in the diagram.

$$\lambda = \frac{v}{f}$$

Question 14
Answer: **Yellow, Red.**
Explanation: Red and green combine via colour addition to give yellow light. Cyan (blue + green) would combine with the third primary colour (red) to make white.

Question 15
Answer: **D**
Explanation: Shorter wavelengths (ie. Blue) are refracted the most, so it would be the most refracted of the three rays (Z). The longest wavelength is red, so it would correspond to ray X.

SECTION B – Detailed Studies

Detailed Study 1 – Astronomy

Question 1
Answer: **A**
Explanation: Ptolemy's Earth centric, circular orbits were in contrast to more modern such as those of Galileo and Copernicus.

Question 2
Answer: **B**
Explanation: Observing the motion of Jupiter's moons enabled Galileo to conclude that they were indeed moons of Jupiter and not the Earth.

Question 3
Answer: **B**
Explanation: Azimuth is measured as the clockwise angle from due North.

Question 4
Answer: **A**
Explanation: Altitude is the angle of elevation from the horizon for the given star.

Question 5
Answer: **B**
Explanation: The stars would appear to rotate clockwise about the South Celestial Pole.

Question 6
Answer: **A**
Explanation: Zenith is a point with an altitude of 90^{o}.

Question 7
Answer: **C**
Explanation: The diurnal motion of the stars is their apparent motion about the celestial poles due to the rotation of the Earth about its own axis.

Question 8
Answer: **A**
Explanation: The annual revolution of the Earth about the Sun causes a secondary apparent motion of the stars due to the varying position of the observer.

Question 9
Answer: **A**
Explanation: The use of mirrors avoids error associated with the different rate of refraction through of various colours through lenses (chromatic aberration).

Question 10
Answer: **B**
Explanation: Apparent magnitude, with smaller or even negative numbers indicating increasing brightness, describe the brightness of a star when viewed from Earth. Absolute magnitude is a standardized brightness – when viewed as though 33 light years away.

Detailed Study 2 – Astrophysics

Question 1
Answer: **C**
Explanation: White Dwarf stars are hot, but very small and not bright compared to our Sun.

Question 2
Answer: **C**
Explanation: Red Giants are much larger and therefore emit more light, even though they are cooler than White Dwarfs.

Question 3
Answer: **D**
Explanation: Given our Sun will NOT end in a supernova due to its relatively small size, the only viable option is White Dwarf (remnant of a Red Giant and planetary nebula).

Question 4
Answer: **A**
Explanation: In a red supergiant, the hydrogen fuel has been exhausted and the star is now seeing fusion of heavier elements, such as carbon to oxygen. Iron is larger than boron, so this is not a viable option.

Question 5
Answer: **A**
Explanation: The image is of a typical spiral galaxy.

Question 6
Answer: **D**
Explanation: These are the accepted, approximate dimensions of the Milky Way galaxy.

Question 7
Answer: **B**
Explanation: Hubble used similar data to conclude that, as distant galaxies are receding faster, there must have been a fixed starting point and subsequent expansion – the Big Bang.

Question 8
Answer: **B**
Explanation: As above. Red shift is due to an object moving away from an observer (Doppler Effect on the frequency of light), so more distant galaxies will be moving more rapidly and thus be more red-shifted.

Question 9
Answer: **B**
Explanation: $d = \frac{1.9 \times 10^{14}}{3.09 \times 10^{13}} = 6.2\ pc$

Question 10
Answer: **A**
Explanation:
$\theta = \frac{1}{d} = \frac{1}{6.2} = 0.16$

Detailed Study 3 – Energy from the nucleus

Question 1
Answer: **D**
Explanation: The strong nuclear force acts over very short distances as is necessary to overcome the electrostatic repulsion of like charges (protons) in the nucleus.

Question 2
Answer: **A**
Explanation: The difference in mass is due to binding energy differences.

Question 3
Answer: **D**
Explanation: The largest element to undergo fusion is Iron.

Question 4
Answer: **D**
Explanation: The material that slows the fast neutrons released during fission is called a moderator.

Question 5
Answer: **A**
Explanation: Total number of nucleons must remain constant.

Question 6
Answer: **C**
Explanation:
$E = 215\times10^{6}\times1.6\times10^{-19}\,J$

$E = 3.44\times10^{-11}\,J$

Question 7
Answer: **B**
Explanation:
$E = mc^2$

$$m = \frac{E}{c^2} = \frac{3.44\times10^{-11}}{\left(3\times10^{8}\right)^2} = 3.8\times10^{-28}\,kg$$

Question 8
Answer: **A**
Explanation: Fission products are regarded as high level radioactive waste as they are usually unstable and will decay.

Question 9
Answer: **D**
Explanation: Reducing the surface area will aid absorption of neutrons and increase the rate of reaction. Cadmium rods (used as control rods in a reactor) will absorb free neutrons and slow the reaction.

Question 10
Answer: **A**
Explanation: Moderator can be heavy water, graphite or other materials which slow, but do not readily absorb neutrons.

Detailed Study 4 - Flight

Question 1
Answer: **C**
Explanation:
$Q = Av = 2.5 \times 21 = 52.5 m^3 s^{-1}$

Question 2
Answer: **B**
Explanation:
$v = \frac{Q}{A} = \frac{52.5}{\pi \times 0.6^2} = 46.4 ms^{-1}$

Question 3
Answer: **A**
Explanation: Lift must exceed weight, given that the craft is accelerating and ascending after takeoff. Weight = 3 x10^6 x 10 = 3 x 10^7 N. So 3.4 x 10^8 N is the most sensible option.

Question 4
Answer: **A**
Explanation: Thrust must exceed drag as the craft should be accelerating forwards as well as upwards after takeoff.

Question 5
Answer: **D**
Explanation: Newtonian lift is generated perpendicular to the sloping aerofoil surface of the wing, directing it up and backwards (partly). The backwards component is induced drag.

Question 6
Answer: **A**
Explanation: Increasing the angle of attack can increase the lift, but will ultimately lead to more turbulence and a stall (no lift).

Question 7
Answer: **B**
Explanation: Ailerons – roll, elevator – pitch, air brake – stop.

Question 8
Answer: **C**
Explanation: 800 x 1.5 = 1200 Nm. The force must be directed upwards on the left wing to counteract the torque on the right.

Question 9
Answer: **C**
Explanation: The air pressure on the top side is less due to the increased speed of the airflow.

Question 10
Answer: **B**
Explanation: Newtonian lift requires the air to be deflected down, thus forcing the wing up.

Detailed Study 5 – Sustainable energy sources

Question 1
Answer: **D**
Explanation: Natural gas, although plentiful, is not replaceable.

Question 2
Answer: **A**
Explanation: Light to electrical energy (at about 15-20% efficiency).

Question 3
Answer: **D**
Explanation: Thermal energy is generally considered low grade, although applications such as geothermal power generations do make use of it.

Question 4
Answer: **B**
Explanation: Potential energy could also include some kinetic due to the motion of the mass.

Question 5
Answer: **A**
Explanation: $E = VIt = 6 \times 1.3 \times 0.6 = 4.68\,J$

Question 6
Answer: **C**
Explanation: $\%Eff = \frac{E_{out}}{E_{in}} = \frac{mgh}{4.68} = \frac{0.25 \times 10 \times 1.4}{4.68} = 75\%$

Question 7
Answer: **B**
Explanation:
$$E = 860 \times 8 \times 7 \times 7 \times 24 \times 60 \times 60 = 1.2 \times 10^9\,J$$
$$E = 1.2 \times 10^3\,MJ$$

Question 8
Answer: **B**
Explanation: $E = \frac{1.2 \times 10^9 \times 16\%}{24 \times 60 \times 60 \times 1000} = 53.9\,kWh$

Question 9
Answer: **B**
Explanation: More constant solar insolation gives a more manageable output.

Question 10
Answer: **A**
Explanation: The majority of the electrical energy is wasted as heat.

Detailed Study 6 – Medical physics

Question 1
Answer: **C**
Explanation: Gamma radiation has the highest penetration power, but lowest ionization ability, so will penetrate from within a patient to detection equipment without causing unwanted ionization of internal structures.

Question 2
Answer: **B**
Explanation: 220 mins is equivalent to two half lives, so the 64 mg will become a quarter of the original value.

Question 3
Answer: **C**
Explanation: 8 mg is an eighth of the original sample, so 3 half lives are required.

Question 4
Answer: **C**
Explanation: The total number of nucleons must be retained.

Question 5
Answer: **D**
Explanation: Alpha particles are "heavy" helium nuclei which have low penetration but high ionization ability.

Question 6
Answer: **B**
Explanation: Shorter half-lives mean higher intensity, but shorter duration.

Question 7
Answer: **A**
Explanation: A coherent bundle will retain the relative position of various pixels and thus deliver an image. An incoherent bundle would lead to a scrambled image.

Question 8
Answer: **A**
Explanation: Lasers are very intense, coherent sources.

Question 9
Answer: **A**
Explanation: X-rays are absorbed by bone and will thus end there, forming a shadow on the film behind the patient.

Question 10
Answer: **A**
Explanation: MRI scans produce higher resolution images of soft tissue such as the brain.