Neap:

Trial Examination 2010

VCE Physics Unit 2

Written Examination

Suggested Solutions

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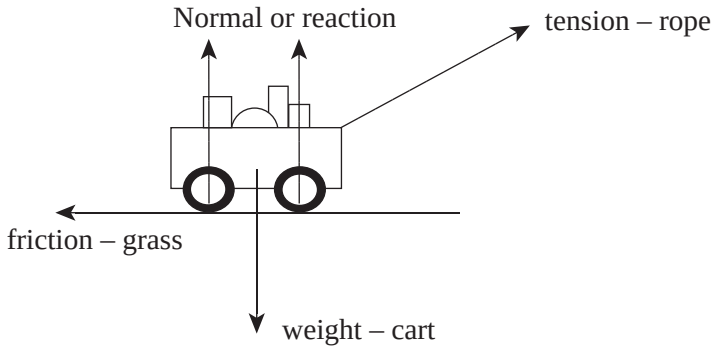
SECTION A – CORE

Area of study 1 – Motion

Question 1



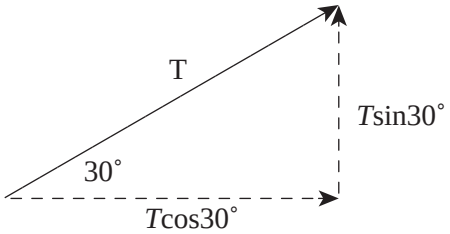
3 marks
1 mark for each correct label

Question 2

$F_{net} = 0$ N 1 mark

since the cart is travelling at a constant speed. 1 mark

Question 3



The rope has both a vertical and horizontal component as shown in the diagram. The horizontal vector is equal to the resistance of the grass so $T\cos 30° = 2$ and $T = \frac{2}{(\cos 30°)} = 2.3$ N.

2 marks
1 mark for demonstrating component vector understanding
1 mark for calculation

Question 4

$W = F \times d = 2 \times 15 = 30$ J 2 marks

1 mark for correct force value
1 mark for calculation

Question 5 D

Since the cart stopped, it has no kinetic energy and thus has only gravitational potential energy. 1 mark

Question 6

Energy = $mgh = 1.3 \times 10 \times 1.5 = 19.5 = 20$ J 2 marks

1 mark for correct values
1 mark for calculation

Question 7

The gravitational potential energy gets converted into kinetic energy so $\text{KE} = \frac{1}{2}mv^2 = 19.5$ J

and rearranging to solve for v gives $v = \sqrt{\frac{2 \times 19.5}{1.3}} = 5.5$ m s^{-1}.

2 marks
1 mark for equating GPE and KE
1 mark for calculation

Question 8

Initial momentum = final momentum

Initial momentum $= mv = 1.3 \times 5.5 = 7.1$ N s^{-1} 1 mark

This is the final momentum so $m_{\text{total}}v_{\text{total}} = \frac{7.1}{m_{\text{total}}} = \frac{7.1}{(1.3 + 1.3)} = 2.7$ m s^{-1}. 1 mark

Note: Alternatively students can note that since the carts are identical in mass, the velocity after the collision must be half the initial velocity.

Question 9

Use straight line equations of motion. The force comes from the friction provided by the grass.

The acceleration is $a = \frac{F}{m} = \frac{-4}{2.6} = -1.54$ m s^{-2} (negative since it's opposite the direction of motion).

1 mark

Now the initial speed (u) is 2.7 m s^{-1} and the final speed (v) is 0 m s^{-1}. 1 mark

Using $v^2 = u^2 + 2ax$, $0 = (2.72)^2 + 2(-1.54)x$ and rearranging $x = \frac{(-2.72)^2}{-3.08} = 2.4$ m. 1 mark

Question 10

$\text{KE}_{\text{initial}}$ is from previous question $\text{KE}_{\text{i}} = 19.5$ J

$\text{KE}_{\text{final}} = \frac{1}{2}mv^2 = \frac{1}{2}(2.6)(2.7)^2 = 9.5$ J 1 mark

Since $\text{KE}_{\text{i}} > \text{KE}_{\text{f}}$ the collision is inelastic. 1 mark

Question 11

The ball that is lifted has gravitational potential energy. As it drops, it loses gravitational energy and gains kinetic energy. 1 mark

As it strikes the stationary ball, the energy is transferred through the balls until it gets to the last ball, then the ball moves away and it loses kinetic energy and gains gravitational energy until it reaches its maximum height. Some energy is lost as sound/heat. 1 mark

Question 12

k is the gradient from the graph. Note that compression needs to be converted into metres. 1 mark

So $k = \frac{F}{x} = \frac{300}{0.05} = 6.0 \times 10^3 \text{ N m}^{-1}$. 1 mark

Question 13

The potential energy from the spring is transferred to the rocket and it converts into gravitational energy as it rises. $U_s = \frac{1}{2}kx^2 = \frac{1}{2}(6000)(0.05)2 = 7.5 \text{ J}$ 1 mark

This equals the GPE of the rocket. So $mgh = \frac{1}{2}kx^2$ and $mgh = 7.5$ and $h = \frac{7.5}{(0.2 \times 10)} = 3.8 \text{ m}$. 2 marks

Question 14

Use the energy to calculate the initial velocity of the rocket. Then use straight-line motion equations to determine time of flight up.

Rearranging kinetic energy equation $v = \sqrt{\frac{2 \times U_s}{m}} = \sqrt{\frac{2 \times 7.5}{0.2}} = 8.66 \text{ m s}^{-1}$ 1 mark

Now use $v = u + at$, where $v = 0$, $u = 8.66$, $a = -10$. Rearrange to solve for t.

$t = \frac{(0 - 8.66)}{-10} = 0.87 \text{ s}$ 1 mark

Now time up = time down, so total flight time = $2 \times 0.87 = 1.7 \text{ s}$. 1 mark

Question 15

Need to impulse (change in momentum) to calculate the force.

$I = \Delta p = m\Delta v = 0.2(8.66) = 1.73 \text{ N s}$ 1 mark

Now $\Delta p = F\Delta t$ and rearrange to find F, so $F = \frac{\Delta p}{\Delta t} = \frac{1.73}{0.25} = 6.9 \text{ N}$. 1 mark

Question 16

Newton's first law is that an object will remain at rest or continue in uniform motion unless acted on by an external force. 1 mark

An object at rest is a special case of zero velocity, and so it is no different to an object in motion. 1 mark

Question 17

Galileo observed that the speed gained by a falling object is independent of its mass, 1 mark
as it is only the force of gravity which accelerates the object, not any other force on the object. 1 mark

Area of study 2 – Wave-like properties of light

Question 1 **D**

Light is a form of electromagnetic radiation. The amplitude of an electromagnetic wave is commonly expressed in terms of the electric field strength. 1 mark

Question 2

$1\lambda = 4$ units

$1\lambda = v / f = \dfrac{(3 \times 10^8)}{7.5 \times 10^{14}}$ 1 mark

$1\lambda = 4 \times 10^{-7}$ m

Multiplication factor is $\times 10^{-7}$. 1 mark

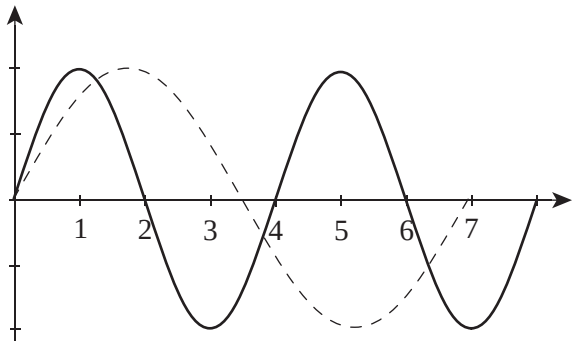
Question 3

$T = \dfrac{1}{f}$

$T = \dfrac{1}{7.5 \times 10^{14} \text{ Hz}}$ 1 mark

$T = 1.3 \times 10^{-15}$ s

Question 4



Sketched waveform should have a longer wavelength of about 7×10^{-12} m. 1 mark

Shows equal amplitude. 1 mark

Question 5

They have the same wave speed (c). 1 mark

They are both forms of electromagnetic radiation. 1 mark

Question 6

350×10^{-9} m 1 mark

Question 7

The name given to this region of the electromagnetic spectrum is ‘ultraviolet light’. 1 mark

Question 8

It will continue straight ahead since the angle of incidence is 0°. 1 mark

Question 9

It will hit side *AC* with an incident angle of 45°.

Since $\sin\theta_c = \frac{1}{1.45}$

$\theta_c = 43.6°$ 1 mark

So, the ray is totally internally reflected. 1 mark

Question 10

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

$\sin i = \sin 25° \times 1.45$ 1 mark

$i = 38°$ 1 mark

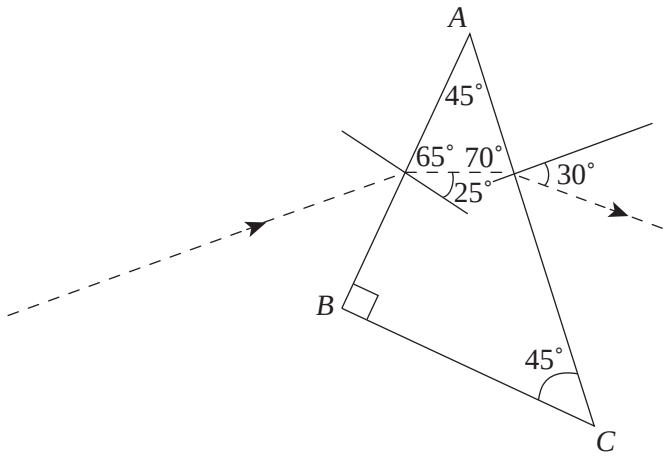
Question 11

At side *AC*, $\theta_i = 20°$ 1 mark

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

$\sin 20 \times 1.45 = \sin r \times 1$ 1 mark

$r = 30°$ 1 mark



Question 12

13° + 10° 1 mark

= 23° (angle of deviation) 1 mark

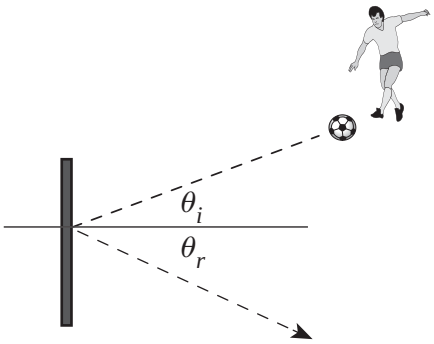
Question 13

White light is made up of many different wavelengths of light.

The shorter wavelengths bend more (more deviation) than the longer ones. 1 mark

The white light is split into the colours of the spectrum as it emerges from side *AC*. 1 mark

Question 14



Shows correct direction so that θ_i is roughly equal to θ_r. 1 mark

Question 15

Light reflects according to the same rule: $\theta_i = \theta_r$ 2 marks

Question 16 **C** 1 mark

Only **C** allows for two different images to be separately viewed through polarisation, because the horizontally polarised filter excludes the polarised light in the vertical plane, and the other eyepiece does the same with the horizontally polarised light. 1 mark

SECTION B – Detailed studies (2 marks for each correct answer)

Detailed study 1 – Astronomy

Question 1 **C**

$$\text{Time} = \frac{\text{distance}}{\text{speed}} = \frac{59\,999 \times 150 \times 10^9 \text{ m}}{3 \times 10^8 \text{ m s}^{-1}} = \frac{3 \times 10^7 \text{ s}}{3600 \times 24} = 347 \text{ days}$$

Question 2 **C**

Earth's atmosphere would absorb most of the IR coming from space. Having the telescope in space enables this IR to be captured and analysed.

Question 3 **A**

Since Earth's atmosphere absorbs light, it would need a larger diameter to achieve the same resolution.

Question 4 **B**

A parabolic mirror would avoid spherical aberration and also chromatic aberration caused by a lens.

Question 5 **B**

Galaxies contain stars, planets and other interstellar material. They are typically of a defined shape; for example the Milky Way has a spiral shape.

Question 6 **A**

To ancient civilisations (like the Greeks), Earth appeared to be stationary while all celestial bodies circled it.

Question 7 **D**

Copernicus' model placed the Sun at the centre, with Earth as one of the planets which revolved around it.

Question 8 **C**

Using Figure 1, Bellatrix lies a little bit less than half-way between 5^h and 6^h and about +7° from 0°.

Question 9 **D**

The declination is similar to latitude and the right ascension is similar to longitude. Azimuth-altitude is a different type of coordinate system.

Question 10 **A**

The slow change in the axis of Earth's rotation (commonly known as the precession of the equinoxes) means star maps are updated on an ongoing basis.

Question 11 **A**

Galileo used two lenses: one a converging lens (objective); the other was diverging (eyepiece).

Question 12 B

A Newtonian telescope uses mirrors with the secondary mirror being a plane type.

Question 13 C

Light entering a telescope is collected in a roughly circular area. Since area of a circle is πr^2 the light collecting power is proportional to r^2.

Detailed study 2 – Astrophysics

Question 1 B

The main reason our sun looks so different is that it is much closer to us than any other star.

Question 2 A

A star that is four times further away should look only $\frac{1}{16}$ times as bright to us even if it has the same luminosity.

Question 3 D

All the assumptions (**A** to **C**) are necessary to make this calculation.

Question 4 B

The nuclear process is fusion. Fusion only happens in the core where the temperature and pressure are sufficiently high.

Question 5 A

Gravity pulls the gas together in a sphere. The nuclear reactions generate lots of heat from inside which provides an outward pressure.

Question 6 C

This reaction is known as the proton–proton chain and generates positrons.

Question 7 C

The HR diagram plots luminosity on the *y*-axis and temperature (or spectral class) on the *x*-axis.

Question 8 C

A movement to the right means a movement against the temperature axis.
On a HR diagram the temperature scale is reversed, so right means cooler.

Question 9 D

A more massive star would be bigger and burn hotter, and as a result it would be more luminous.
So statement **I** is correct.

A less massive star would burn its fuel more slowly and would therefore be on the main sequence for longer.
So statement **II** is also correct.

Question 10 D

Hubble (and Henrietta Leavitt) needed to do all three (**A** to **C**) to work out the distances to some of our nearest galaxies.

Question 11 B

Red shift is an indication of receding velocity.

Question 12 A

Hubble's law shows that the further a galaxy is away from us, the greater its speed of recession is.
This shows that the Universe is expanding.

Question 13 C

The idea of a Steady State universe was required to allow for an expanding universe but without a change in overall density.

Detailed study 3 – Energy from the nucleus

Question 1 C

A nuclear power plant would generate electricity.

Question 2 C

The largest problem is the containment of the particles (plasma) at the extreme temperatures required to achieve fusion.

Question 3 A

Four neutrons are released in this reaction. This is calculated by adding the mass numbers on both sides.

Question 4 D

The mass should be greater than the critical mass.
The shape should be spherical to achieve greatest probability of neutron capture.

Question 5 D

Pu-239, like U-235, can split into two after capturing a neutron.

Question 6 A

The mass defect (difference) is then converted to energy.

Question 7 B

U-238 can be used to produce Pu-239 in a fast breeder reactor.

Question 8 C

The fuel rods are surrounded by a moderator material that slows down the fast neutrons.

Question 9 C

The control rods absorb slow neutrons and so slow down the reaction rate in the core.

Question 10 A

Must be fissionable material.

Question 11 D

The main reason for the concrete shell is to contain the nuclear material and radiation from the environment.

Question 12 A

Hot water or steam is carried off to a turbine to drive the generator.

Question 13 B

One of the main disadvantages of nuclear energy is the problem of long lasting nuclear waste for which there is currently no acceptable solution.

Detailed study 4 - Investigations: Flight

Question 1 C

For lift to occur there must be a pressure differential; in this case pressure is higher below the wing than above.

Question 2 C

The wing pushes the air down (action). By Newton's third law the opposite reaction is the air pushing up on the wing thus generating lift.

Question 3 A

A cap reduces the skin drag by improving the smoothness of the surface around the swimmer's head.

Question 4 D

Three statements (**A** to **C**) are correct.

Question 5 C

lift = weight = mg = 10 000 × 10 = 100 kN

Question 6 B

$$P = Fv = 8 \times 10^3 \times \frac{540}{3.6} = 1.2 \text{ MW}$$

Question 7 B

Pitch is motion about the lateral axis.

Question 8 B

The elevators are used to adjust the pitch.

Question 9 **C**

glide ratio = $\frac{\text{glide distance}}{\text{loss of altitude}} = \frac{2200}{200} = 11$. It has a glide ratio of 11:1.

Question 10 **C**

The combined skin/form drag increases roughly as the square of the speed.

Question 11 **C**

$$C_L = \frac{10^5}{\frac{1}{2}(1.22)(150)^2(9.11)} = 0.799 = 0.8$$

Question 12 **A**

Use the graph supplied and with C_L of 0.8, the angle of attack is 2.5°.

Question 13 **D**

The plane will eventually reach a point where it will stall.

Detailed study 5 - Investigations: Sustainable energy sources

Question 1 **C**

Nuclear is the only non-current energy source in Australia; the rest are currently in use.

Question 2 **A**

Solar produces no greenhouse gases, and natural gas produces less than coal.

Question 3 **D**

The quantity of coal required is $\frac{1500}{30}$ = 50 kg s^{-1} × (3600) = 180 000 kg h^{-1} = 180 tonnes h^{-1}. Since it is only 33% efficient, the actual quantity of coal needed is 180 ÷ 0.33 = 545 tonnes.

Question 4 **B**

10% of 1.8×10^{17} W = 1.8×10^{16} W

Number of power stations = $\frac{1.8 \times 10^{16}}{1.5 \times 10^9} = 1.2 \times 10^7 = 12$ million .

Question 5 **C**

At 25% efficiency, 0.25 × 1000 = 250 W is converted into electricity.

Question 6 **A**

Sunlight (photosynthesis) is used by plants to create energy stored in a chemical form.

Question 7 **B**

Biofuels take up land that can be used to produce food.

Question 8 **B**

The 'regenerative braking' converts the kinetic energy of the car during braking into stored electrical energy in a battery.

Question 9 **B**

As hydrogen gas on its own is not readily available, it must be produced and this is its major problem.

Question 10 **A**

Power is 1.5 MW and Power = force × speed, so $F = \frac{1.5\ \text{MW}}{3} = 0.5\ \text{MW}$.

Question 11 **A**

Efficiency would be calculated using the forces, so $\frac{0.5}{1.8} = 0.277 \times 100 = 28\%$.

Question 12 **D**

The higher speed of the water provides more force to turn the turbines.

Question 13 **B**

Solar generation is restricted to daylight hours, whereas the tidal turbine can run all the time.

Detailed study 6 - Medical physics

Question 1 **C**

Radio pharmaceuticals are not for sale in pharmacies, but clinicians can use them in hospitals to help them diagnose and treat patients.

Question 2 **C**

Only gamma rays are used for this purpose. Gamma rays are highly penetrating and therefore cause less damage as they are less absorbed by the body tissues. Particulate forms of radiation are not used as tracers because they are too easily absorbed.

Question 3 **D**

Answers **A**, **B** and **C** all are good reasons to use Tc-99.

Question 4 **B**

Length of exposure is an important factor in reducing the harmful effects of radiation.

Question 5 C

The relative refractive index is $\frac{1.55}{1.42}$.

Question 6 B

Water or grease – or other substances with a lower refractive index – coming into contact with the core can easily cause significant loss of light.

Question 7 A

Only coherent bundles can carry the image. The integrity of the image must be kept intact so the pixels are not 'shuffled' by the incoherence of the optical fibre bundle.

Question 8 D

Light is required to see inside the body.

Question 9 C

The site of operation often needs to be 'inflated' so that more space is available for the surgeon.

Question 10 C

Computer-aided design (CAD) and medical lasers are not imaging techniques.

Question 11 A

High atomic number elements are better absorbers of X-rays.

Question 12 C

CT, or computer tomography, is an X-ray based imaging technique capable of providing three-dimensional imaging.

Question 13 D

Multiple beam therapy is used so that surrounding tissues get a much lower dose than the tumour.