Trial Examination 2014

VCE Physics Unit 2

Written Examination

Suggested Solutions
**AREA OF STUDY 1 – MOTION**

**Question 1 (6 marks)**

a. The phone has reached terminal velocity when the air resistance equals the weight of the phone, making the net force 0 N. 1 mark
This means the acceleration is also 0 m s\(^{-1}\) and its speed will not change. 1 mark

b. 0 N 1 mark

c. \[ t = \frac{d}{v} \]
\[ = \frac{(324 - 100) \text{ m}}{30 \text{ m s}^{-1}} \]
\[ = 7.5 \text{ s} \] 1 mark

d. The correct answer is C. 1 mark

**Question 2 (14 marks)**

a. \[ E = mgh \]
\[ = 2.5 \times 10 \times 75 \]
\[ = 1875 \text{ J} \] 1 mark

b. \[ P = \frac{E}{t} \]
\[ = \frac{(6000 \times 2.5 \times 10 \times 75) \text{ J}}{(4 \times 3600) \text{ s}} \]
\[ = 780 \text{ W} \] 2 marks
At least 780 W is required.

c. Vertical lift: Lifting force is equal to weight. 1 mark
Angled lift: Lifting force is less than weight. 1 mark

\[ \text{lifting force} \]
\[ \text{lift force} \]
\[ \text{normal force} \]
\[ \text{weight} \]

\[ \text{weight} \]

2 marks
1 mark for correct diagram
1 mark for correct labels

\[ v = \sqrt{(2gh)} \]
\[ = \sqrt{20 \times 75} \]
\[ = 39 \text{ m s}^{-1} \] 1 mark

d. The motor would still require the same power 1 mark
because the amount of energy transferred is still the same. The smaller force is countered by the larger distance. 1 mark

e. \[ v = \sqrt{(2gh)} \]
\[ = \sqrt{20 \times 75} \]
\[ = 39 \text{ m s}^{-1} \] 1 mark
f. \[ k = \frac{2(mgh)}{x^2} \]
\[ = \frac{2(2.5 \times 10 \times 75)}{1.5^2} \]
\[ = 1667 \text{ N m}^{-1} \]

**Question 3 (18 marks)**

a. \[ p = mv \]
\[ = 50 \times 7000 \]
\[ = 3.5 \times 10^5 \]

b. \( \Delta p_{\text{dust}} = \Delta p_{\text{Ryan}} \)
\[ m_{\text{dust}} \times 6800 \text{ m s}^{-1} = 50 \times 20 \text{ m s}^{-1} \]
\[ m_{\text{dust}} = 1.5 \text{ kg} \]

b. \[ F = \frac{\Delta p}{t} \]
\[ = \frac{10000 \text{ kg m s}^{-1}}{120 \text{ s}} \]
\[ = 83 \text{ N} \]

c. \[ a = \frac{F}{m} \]
\[ = \frac{83 \text{ N}}{50} \]
\[ = 1.7 \text{ m s}^2 \]

d. \[ t = \frac{\text{distance}}{\text{speed}} \]
\[ = \frac{1700}{200} \]
\[ = 8.5 \text{ s} \]

e. \[ a = \frac{v}{t} \]
\[ = \frac{2 \times 2000}{8.5^2} \]
\[ = 55 \text{ m s}^2 \]

f. \[ v = at \]
\[ = 55 \times 8.5 \]
\[ = 470 \text{ m s}^{-1} \]

As Matt grabs hold of Ryan he exerts a force on her. According to Newton’s third law Ryan will exert an equal force on Matt, but in the opposite direction.

h. 1 mark
i. Reason 1: Matt started his journey while his velocity relative to the shuttle was 0 m s \(^{-1}\). When he gets to Ryan he has a large velocity away from the shuttle. Before he can head back he needs to reduce his outward velocity to 0 m s \(^{-1}\). This takes time. 1 mark

Reason 2: While Matt and Ryan are decelerating relative to the shuttle, they are moving away from it. This makes the homeward journey much longer in distance. 1 mark

Reason 3: Since the jet pack has only one thrust level, the same force now has to accelerate a greater mass of the two astronauts combined. This results in a lesser acceleration. 1 mark

**AREA OF STUDY 2 – WAVE-LIKE PROPERTIES OF LIGHT**

**Question 1 (5 marks)**

a. 1.5 m. Amplitude is half the wave size. 1 mark

b. \[ f = \frac{1}{T} \]

\[ = \frac{1}{4} \]

\[ = 0.25 \text{ s} \] 1 mark

c. \[ \lambda = \frac{v}{f} \]

\[ = \frac{5.1}{0.25} \]

\[ = 20.4 \text{ m} \] 1 mark

*Note: consequential from part b.*

d. The correct answer is B. 1 mark

Waves transfer energy but not matter.

**Question 2 (3 marks)**

With no cladding:

\[ \theta_c = \sin^{-1}\left(\frac{1}{1.48}\right) \]

\[ = 42.5^\circ \] 1 mark

With cladding taken into account:

\[ \theta_c = \sin^{-1}\left(\frac{1.46}{1.48}\right) \]

\[ = 80.6^\circ \] 1 mark

increase in angle = 80.6 \(\text{ }\) 42.5 = 38.1\(^\circ\) 1 mark

**Question 3 (2 marks)**

The correct answer is B. 2 marks

The speed remains constant (speed of light) so by the wave equation \( c = \lambda f \), if \( \lambda \) is longer (since 2920 nm is a longer wavelength than visible light), its frequency must decrease.
Question 4 (3 marks)
Unpolarised light has multiple planes of vibration. 1 mark
The filter allows one mode of vibration through (optional either horizontal or vertical). 1 mark

![Unpolarised light, polaroid filter, polarised light](image)

Question 5 (11 marks)
a. The correct answer is A. 2 marks
The relationship between $i$ and $r$ is not linear, constant, or does not decrease as incident angle increases.
b. Use Snell’s law:
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$
$$1.00 \sin (25^\circ) = n_2 \sin (18.2^\circ)$$
Re-arranging and solving for $n_2$,
$$n_2 = \frac{1.00 \times \sin (25.0^\circ)}{\sin (18.2^\circ)}$$
$$= 1.35 \text{ (to 2 decimal places)}$$
c. Use Snell’s law:
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$
$$1.35 \sin (18.2^\circ) = 1.00 \sin (\theta^\circ)$$
Re-arranging and solving for $\theta$,
$$\theta = \sin^{-1} \left( \frac{1.35 \times \sin (18.2^\circ)}{1.00} \right)$$
$$= 25.0^\circ \text{ (accept } \pm 0.5^\circ\text{)}$$
d. It will be totally internally reflected and stay within the water and not come out of that medium. 1 mark

e. Two of the images come from refraction (dotted lines). One image comes from (total internal) reflection. 3 marks

1 mark for each correct line
Question 6 (2 marks)
The particle model predicts that the speed of the light should increase and it should bend away from
the normal. 1 mark
This is the opposite to what occurs with light and so the particle model cannot describe the
refraction of light correctly. 1 mark

Question 7 (4 marks)
a. The term used is ‘dispersion’. 1 mark
   Each colour is refracted by different amounts by the prism and so separates as they travel
   through it. 1 mark
b. Yes the speeds differ. 1 mark
   Each colour has a different speed; red is diffracted less and so travels faster. (Accept vice versa
   explanation for violet.) 1 mark
SECTION B – DETAILED STUDIES (2 marks for each correct answer)

Detailed study 1 – Astronomy

Question 1  A
The AU is the shortest, the light-year is longer and the parsec is the longest.

Question 2  D
All use some form of light (electromagnetic radiation).

Question 3  B
The different wavelengths present in white light causes chromatic aberration.

Question 4  C
Increasing the diameter makes the f-number smaller. This allows more light to be available to form an image.

Question 5  A
At 9 am the altitude is approximately 23° at an azimuth (east) of 75°.

Question 6  B
The Sun travels east to west.

Question 7  A
The Earth’s tilt on its axis changes the Sun’s relative position overhead.

Question 8  C
X-rays do not penetrate the atmosphere.

Question 9  D
The visible light only provides a narrow range of information of the entire electromagnetic spectrum.

Question 10  A
Neutron stars can be directly observed; black holes cannot be seen directly.

Question 11  A
Epicycles were needed to explain Mars’s retrograde motion if it orbited the Earth.
Detailed study 2 – Astrophysics

Question 1  C
The x-axis must be wavelength and the y-axis must be intensity.

Question 2  B
Using Wien’s law, the wavelength at which the intensity is highest can be used to calculate the surface temperature of a star.

Question 3  D
Options A–C are all correct.

Question 4  A
Our Sun will eventually swell up to become a red giant star.

Question 5  C
This is the only possible correct answer.

Question 6  A
The average mass must decrease as energy is released.

Question 7  B
The red shift of hydrogen lines tells us that galaxies are moving away from us.

Question 8  B
The nearer galaxies must move slower (except for the very close ones in our local group, but Hubble’s law does not hold for those galaxies).

Question 9  A
Hubble’s law shows that the universe is expanding.

Question 10  C
Cosmic background radiation was one of the observations that finally showed that the Steady State theory must be wrong.

Question 11  C
Because of the Inverse-Square Law of Light, galaxy X must be 20 times closer to the Earth compared to galaxy W.
Detailed study 3 – Energy from the nucleus

Question 1       D
Nuclei that undergo fusion are smaller than iron, while nuclei that undergo fission are larger than iron.

Question 2       A
Graph A shows the electrostatic force between protons and Graph B the nuclear force.

Question 3       C
As you increase mass, energy increases in direct proportion.

Question 4       D
Reaction 2 describes the fusion process.

Question 5       C
Reaction 1 is a fission process; it does not require the same high temperature as fusion.

Question 6       C
Plutonium ores can only be made artificially.

Question 7       A
The nuclear energy heats up the water, which drives a turbine (kinetic). This turbine then generates electricity.

Question 8       D
In human terms, some of the by-products of nuclear reactors have very long half-lives.

Question 9       D
Fast-breeder reactors require fast-moving neutrons.

Question 10      A
The shape would allow neutrons to escape and not continue the chain reaction.

Question 11      B
Chain reaction is the term most commonly used.
Detailed study 4 – Investigations: Flight

Question 1  B
The four main forces are lift, weight, drag and thrust.

Question 2  C
Lift is proportional to wing area. Drag is proportional to cross-sectional surface area.

Question 3  C
Answer found by vector subtraction.

Question 4  C
change in momentum of aircraft = change in momentum of air = impulse on aircraft

Question 5  A

\[
\text{lift} \quad \uparrow \quad \text{impulse on aircraft} \\
\text{drag}
\]

Question 6  B
Object \( Y \) will experience laminar flow and as a result experience smaller drag forces.

Question 7  A
Drag is a force, hence N (Newton) is the correct unit.

Question 8  C
There are only vertical forces in this example and the lift (upward) force must be greater than weight.

Question 9  C
Without a tail rotor the torque from the main rotor would cause the helicopter to twist around its vertical axis.

Question 10  D
To provide the lift, the wing profile should move to the right.

Question 11  D
The shape causes the air above the wing to have a greater speed and therefore lower pressure than below the wing.
Detailed study 5 – Investigations: Sustainable energy sources

Question 1  C
By far the largest component of the remaining energy is thermal in nature.

Question 2  C
\[
\frac{4}{80} = 0.05 \text{ or } 5\%
\]

Question 3  D
The useful output of a wind turbine is electrical energy.

Question 4  B
Average domestic power use is roughly 1 kW.
So \[
\frac{10 \text{ MW}}{1 \text{ kW}} = 10000 \text{ homes}
\]

Question 5  D
Energy available per second \[
= \frac{100 \times 60 \times 0.1 \times 10}{2} = 3000 \text{ W}
\]

Question 6  B
Low-grade heat can only feasibly be used as a complementary heat source.

Question 7  B
\[
\frac{200 \text{ GWh}}{(365 \times 24)h} = 22.8 \text{ MW}
\]

Question 8  A
The proposed power station will harvest the available gravitational potential energy from the sea water.

Question 9  B
The sea water would flow from the high water basin to the low water basin through the turbines.

Question 10  D
While geothermal is sustainable (it has no detrimental environmental effects), it cannot be renewed. The hot rocks on which it relies will eventually cool.

Question 11  B
A and B are not true and D is not relevant since modern transport fuels are already lead-free.
Detailed study 6 – Medical physics

Question 1 D
Options A–C are all good precautions.

Question 2 C
Greater energy is required to break up kidney stones than for a normal scan.

Question 3 B
Laser can be used safely to remove tattoos.

Question 4 D
Ultrasound has the emitter and detector together, the X-ray is separate and an MRI has a ring around the patient (body tissue).

Question 5 A
Electrons are rapidly slowed down as they collide with the target, and in the process X-rays are produced.

Question 6 B
Most of the energy input is converted into heat (thermal energy).

Question 7 D
Pregnant females need to avoid unnecessary exposure to radiation such as X-rays as the foetus may be harmed.

Question 8 C
Low half-life means less exposure to radiation for the patient.

Question 9 A
Positrons would interact with electrons in the environment and those gamma rays produced would not help in diagnosis.

Question 10 C
TIR allows the object to be viewed.

Question 11 B
A, C and D are only rotated, whilst B is reflected and thus incorrect.