Neap:

Trial Examination 2015

VCE Physics Unit 2

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section		Number of questions	Number of questions to be answered	Number of marks
A – Motion		4	4	38
Wave-like properties of light		6	6	30
	Number of detailed studies	Number of detailed studies to be answered	Number of questions to be answered	Number of marks
B – Detailed studies	6	1	11	22
				Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, one folded A3 sheet or two A4 sheets of notes and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 46 pages including formulae, data and a periodic table at the front.

Answer sheet for multiple-choice questions.

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on your answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

MOTION

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v + u)t$
3	Newton's second law	$\Sigma F = ma$
4	gravitational potential energy near the surface of Earth	mgh
5	kinetic energy	$\frac{1}{2}mv^2$
6	mechanical work	$W = Fx$
7	power	$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$
8	acceleration due to gravity	$g = 10 \text{ m s}^{-2}$
9	Hooke's law	$F = -kx$
10	elastic potential energy	$\frac{1}{2}kx^2$

WAVE-LIKE PROPERTIES OF LIGHT

Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
universal wave equation	$v = f\lambda$
frequency and period	$f = \frac{1}{T}$
refractive index	$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in the medium}}$

ASTRONOMY

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

ASTROPHYSICS

speed of light in vacuum	$c = 3.0 \times 10^8 \text{ m s}^{-1}$

ENERGY FROM THE NUCLEUS

mass–energy equation	$E = mc^2$

FLIGHT

power	$P = \frac{E}{t}$ or $P = Fv$
Bernoulli's equation	$\frac{1}{2}\rho v_1^2 + \rho g h_1 + P_1 = \text{constant}$
torque	$\tau = F \times r$
glide ratio (lift-to-drag ratio)	$\text{glide ratio} = \frac{\text{glide distance}}{\text{loss of altitude}}$

SUSTAINABLE ENERGY SOURCES

$$\text{efficiency (\%)} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

PREFIXES

Prefix	Abbreviation	Value
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

THE PERIODIC TABLE OF THE ELEMENTS

Key: atomic number — 79; symbol of element — Au; relative atomic mass — 197.0; name of element — gold

1 H 1.0 hydrogen																	2 He 4.0 helium
3 Li 6.9 lithium	4 Be 9.0 beryllium											5 B 10.8 boron	6 C 12.0 carbon	7 N 14.0 nitrogen	8 O 16.0 oxygen	9 F 19.0 fluorine	10 Ne 20.2 neon
11 Na 23.0 sodium	12 Mg 24.3 magnesium											13 Al 27.0 aluminium	14 Si 28.1 silicon	15 P 31.0 phosphorus	16 S 32.1 sulfur	17 Cl 35.5 chlorine	18 Ar 39.9 argon
19 K 39.1 potassium	20 Ca 40.1 calcium	21 Sc 44.9 scandium	22 Ti 47.9 titanium	23 V 50.9 vanadium	24 Cr 52.0 chromium	25 Mn 54.9 manganese	26 Fe 55.8 iron	27 Co 58.9 cobalt	28 Ni 58.7 nickel	29 Cu 63.5 copper	30 Zn 65.4 zinc	31 Ga 69.7 gallium	32 Ge 72.6 germanium	33 As 74.9 arsenic	34 Se 79.0 selenium	35 Br 79.9 bromine	36 Kr 83.8 krypton
37 Rb 85.5 rubidium	38 Sr 87.6 strontium	39 Y 88.9 yttrium	40 Zr 91.2 zirconium	41 Nb 92.9 niobium	42 Mo 95.9 molybdenum	43 Tc 98.1 technetium	44 Ru 101.1 ruthenium	45 Rh 102.9 rhodium	46 Pd 106.4 palladium	47 Ag 107.9 silver	48 Cd 112.4 cadmium	49 In 114.8 indium	50 Sn 118.7 tin	51 Sb 121.8 antimony	52 Te 127.6 tellurium	53 I 126.9 iodine	54 Xe 131.3 xenon
55 Cs 132.9 caesium	56 Ba 137.3 barium	57 La 138.9 lanthanum	72 Hf 178.5 hafnium	73 Ta 180.9 tantalum	74 W 183.8 tungsten	75 Re 186.2 rhenium	76 Os 190.2 osmium	77 Ir 192.2 iridium	78 Pt 195.1 platinum	79 Au 197.0 gold	80 Hg 200.6 mercury	81 Tl 204.4 thallium	82 Pb 207.2 lead	83 Bi 209.0 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon
87 Fr (223) francium	88 Ra (226) radium	89 Ac (227) actinium	104 Rf (261) rutherfordium	105 Db (262) dubnium	106 Sg (263) seaborgium	107 Bh (264) bohrium	108 Hs (265) hassium	109 Mt (268) meitnerium	110 Ds (271) darmstadtium	111 Rg (272) roentgenium	112 Uub		114 Uuq		116 Uuh		118 Uuo

58 Ce 140.1 cerium	59 Pr 140.9 praseodymium	60 Nd 144.2 neodymium	61 Pm (145) promethium	62 Sm 150.3 samarium	63 Eu 152.0 europium	64 Gd 157.2 gadolinium	65 Tb 158.9 terbium	66 Dy 162.5 dysprosium	67 Ho 164.9 holmium	68 Er 167.3 erbium	69 Tm 168.9 thulium	70 Yb 173.0 ytterbium	71 Lu 175.0 lutetium
90 Th 232.0 thorium	91 Pa 231.0 protactinium	92 U 238.0 uranium	93 Np 237.1 neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (251) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium	103 Lr (260) lawrencium

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SECTION A – Core studies

Instructions for Section A

Answer **all** questions in this section in the spaces provided. Write using black or blue pen.

Where an answer box has a unit printed in it, give your answer in that unit.

You should take the value of g to be 10 m s^{-2}.

Where answer boxes are provided, write your final answer in the box.

In questions worth more than 1 mark, appropriate working should be shown.

Unless otherwise indicated, diagrams are not to scale.

Area of study – Motion

Question 1 (15 marks)

Jill is riding her bicycle up a hill. Her velocity at the base of the hill is 10 m s^{-1}. By the time she reaches the top, her velocity has dropped to 3.0 m s^{-1} and she has travelled 70 m. Assume her acceleration is uniform.

a. Calculate the acceleration Jill experienced while she was cycling uphill. 2 marks

m s^{-2}

b. How long did it take Jill to climb the hill on her bicycle? 2 marks

s

Jill and her bicycle have a combined mass of 55 kg.

c. Calculate the average magnitude of the net force acting on Jill and her bicycle whilst climbing the hill. 2 marks

N

d. What power does the net force exert? 2 marks

W

e. What is the most important energy conversion that is achieved by the net force? 1 mark

_____

_____

Jill meets up with Jack, who is also on a bicycle, and together they ride down the other side of the hill. After 4 seconds Jill uses her brakes to allow Jack to catch up. The graph in Figure 1 shows the velocity of both Jill and Jack from the moment they ride down the hill.

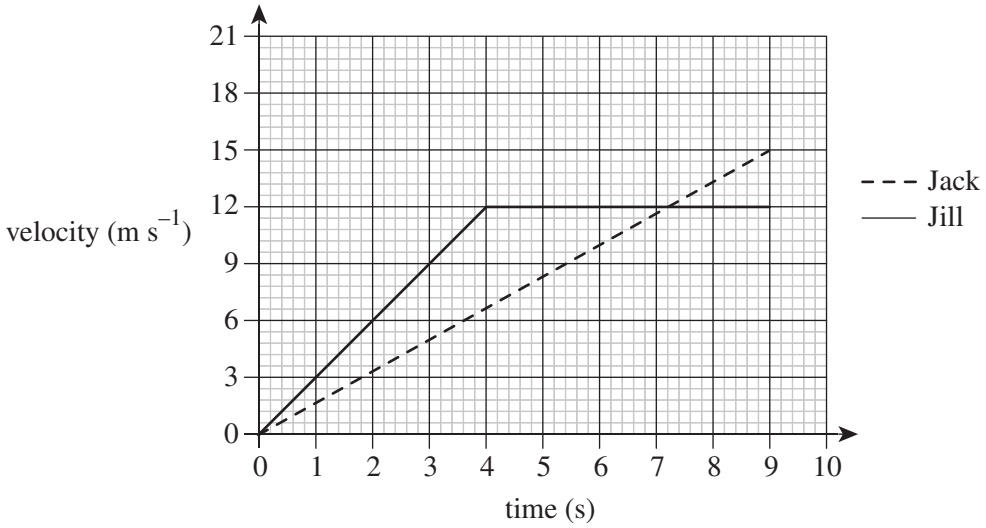

Figure 1

f. Calculate Jack's acceleration as he comes down the hill. 2 marks

m s^{-2}

g. Show, using calculations, that Jack has not yet overtaken Jill after 9 seconds. 3 marks

h. What is the net force on Jill at 7 seconds? 1 mark

N

Question 2 (6 marks)

Newton's third law states that for every action force there should be an equal and opposing reaction force. For each of the following action forces, state the reaction force and its direction.

a. The Earth gravitationally attracts the Moon. 2 marks

Reaction:

_____

Direction:

_____

b. A footballer kicks a ball up into the air. 2 marks

Reaction:

_____

Direction:

_____

c. A weight force acts on a falling apple. 2 marks

Reaction:

_____

Direction:

_____

Question 3 (9 marks)

A jet engine burns fuel and pushes the exhaust gases out of the back of the engine. The engine provides an impulse to the exhaust gases, and in return those gases provide an impulse to the engine.

a. What can be said about the two impulses involved in this interaction between exhaust and engine? 2 marks

_____

_____

When the engine is mounted on a test rig, it experiences an average force of 4000 N over a period of 1 minute.

b. Calculate the impulse on the engine. Provide an appropriate unit with your answer. 3 marks

The engine is now mounted on a low-friction trolley. The engine and trolley are fired and after 30 seconds, their speed is measured to be 120 m s^{-1}. (Ignore the change of mass that occurs to the engine as a result of burning the fuel.)

c. Calculate the combined mass of the engine and trolley. 2 marks

kg

Four of the engines are used to power an aeroplane. The total mass of the plane is 2.0×10^4 kg.

d. How long will the engines have to fire for the aeroplane to reach a take-off speed of 80 m s^{-1}? 2 marks

s

Question 4 (8 marks)

Kite surfers use a large kite powered by the wind to propel themselves across the surface of the sea. One such surfer's kite is pulling him at an angle of 50° from the horizontal. This is shown in Figure 2 below. Assume the wind direction is the same as the direction of travel by the kite surfer.

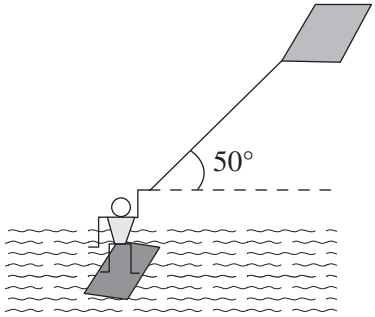

Figure 2

a. Assuming the tension force in the rope attached to the kite is 150 N, and the kite surfer is moving along the surface at a constant speed of 12 m s^{-1}, calculate how much work is done by the kite on the kite surfer in a 5-second period. 3 marks

J

b. If the surfer has a mass of 65 kg, what is their kinetic energy after 5 seconds? 2 marks

J

When the wind suddenly drops, the kite stops pulling and the surfer slows to a stop over 20 m.

c. Calculate the average friction force experienced by the surfer during this time. 2 marks

N

d. What assumption(s) did you have to make in order for you to calculate an answer to part **c.**? 1 mark

_____

_____

Area of study – Wave-like properties of light

Question 5 (4 marks)

Two square-type waves of length 1 cm are approaching each other as shown in Figure 3 below.

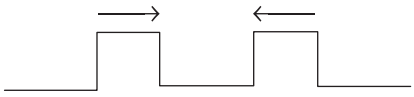

Figure 3

a. What is the amplitude of this superimposed wave? 1 mark

cm

b. Sketch a diagram of when the two waves are fully superimposed on each other, labelling all appropriate dimensions. 2 marks

c. What type of wave behaviour describes what occurs when the two waves are superimposed on each other? 1 mark

_____

Question 6 (9 marks)

Alastair is a keen swimmer who is doing laps at his local pool. Karl, who is standing outside of the pool, notices that the waves Alastair generates occur (on average) every 0.4 of a second. He estimates the distance between successive wave crests to be 30 cm.

a. What is the wavelength of the waves being produced? 1 mark

m

b. What is the frequency of the waves? 1 mark

Hz

c. What is the speed of the waves Alastair is generating? 1 mark

$m\ s^{-1}$

Alastair suddenly stops swimming and jumps up and down on the spot. Karl notices the pattern of the waves as they approach the edge of the pool. The pattern is shown in Figure 4 below.

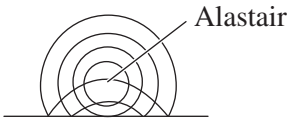

Figure 4

d. Explain what is happening to the waves as they approach the edge of the pool to produce the pattern seen in Figure 4. 2 marks

_____

_____

_____

The pool has another edge where it suddenly changes depth. Figure 5 shows how the wave pattern changes as the depth changes.

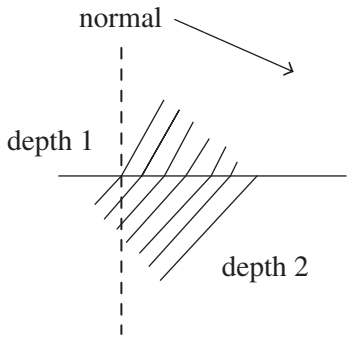

Figure 5

e. Explain what is happening to the wave pattern as it changes depth. Ensure you make reference to the relevant physics phenomenon in your explanation. 2 marks

_____

_____

_____

f. Given the frequency of the wave pattern in Figure 5 was 3.75 Hz, and the wave fronts go from being 0.35 m to 0.25 m apart, what is the value of $\frac{\text{speed before change}}{\text{speed after change}}$? 2 marks

Question 7 (4 marks)

A large fish tank is seen by a person walking their dog at night. Figure 6 shows the fish tank when viewed from the side. The light sends two beams to the surface (n_{air} = 1.00, n_{water} = 1.33).

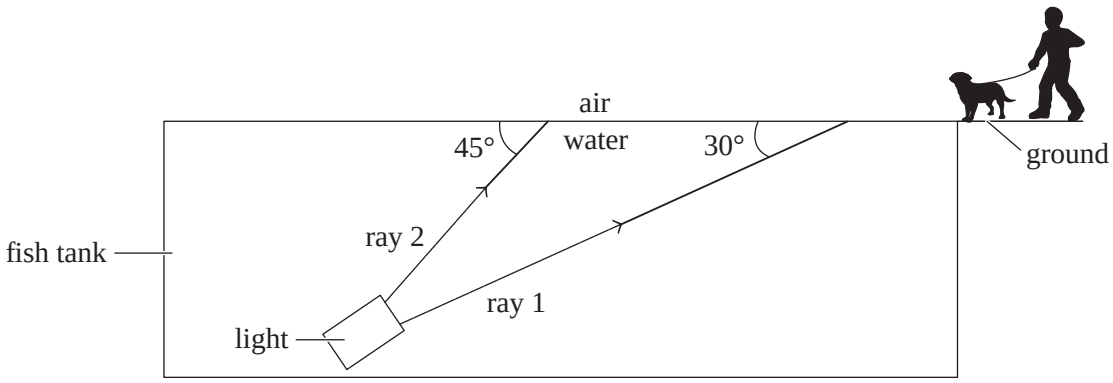

Figure 6

a. Show, with at least one calculation, whether the person standing at the edge of the pool will see ray 1, ray 2, or both rays. 2 marks

_____

_____

_____

_____

_____

b. If white light is used (and assuming it now exits the water), describe what happens to the light as viewed by the person walking above. 2 marks

_____

_____

_____

_____

Question 8 (6 marks)

'Radar' is an acronym for 'ra(dio) d(etection) a(nd) r(anging)'. Radar can be used to estimate the distance of an aircraft from an airport. In one instance, a radio wave of wavelength 1.12 cm was sent out and a signal was received 37.33 μs (microseconds) later.

a. How far is the aircraft from the airport? 2 marks

km

b. Circle the correct bolded options for the following sentence:

Radio waves and visible light **travel / do not travel** at the same speed through a vacuum, and both **would / would not** refract by the same amount if moving from an air to a water medium. 2 marks

c. Circle on Figure 7 below where radio-wave frequencies are approximately located on the electromagnetic spectrum. 2 marks

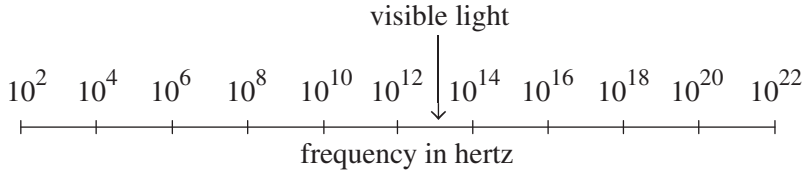

Figure 7

Question 9 (3 marks)

Light that is reflected off the surface of water is usually horizontally polarised, as shown in Figure 8.

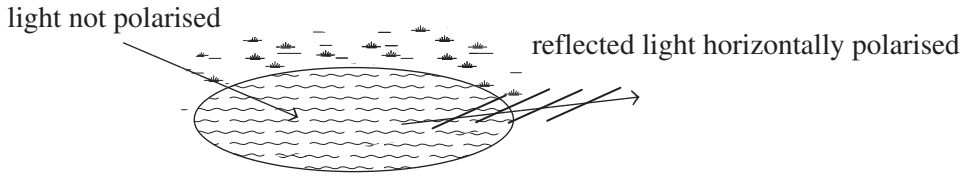

Figure 8

This reflected light is the source of glare coming off of the water. Manufacturers of sunglasses reduce glare by making polarising sunglasses.

a. In what direction should the polarising lens in the sunglasses be oriented? Show this by drawing the direction in the glasses in Figure 9. 1 mark

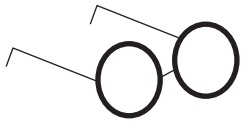

Figure 9

b. Explain your answer to part **a.** 2 marks

_____

_____

_____

Question 10 (4 marks)

M_A and M_B are two plane mirrors, placed apart as shown in Figure 10. An object R is placed facing M_B.

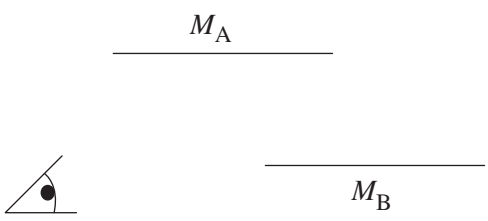

Figure 10

a. Using the particle model, draw on Figure 10 how an observer can see the object reflected in M_A. 2 marks

b. Explain whether object R seen in M_A is the mirror image (that is, reversed) or not. 2 marks

_____

_____

_____

SECTION B

Instructions for Section B

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Show the Detailed study you are answering by shading the matching box on your multiple-choice answer sheet and writing the name of the Detailed study in the box provided.

Choose the response that is **correct** for the question.

A correct answer scores 2, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

You should take the value of g to be 10 m s^{-2}.

Detailed study 1 – Astronomy

Question 1

The word 'planet' is derived from Ancient Greek and means 'wanderer', as these objects appeared to move differently to the other stars in the sky.

One of the first people to notice that planets were actually similar to Earth was

A. Galileo.
B. Aristotle.
C. Newton.
D. Einstein.

Question 2

Copernicus is credited with fundamentally changing our understanding of the universe. However, he did have some incorrect ideas, one of them being that the Sun was at the centre of the universe and it did not move. His model was, however, an improvement on the one that was accepted up until that time.

The person and model that Copernicus' model replaced was

A. Ptolemy and the heliocentric model.
B. Aristotle and the geocentric model.
C. Aristotle and the heliocentric model.
D. Ptolemy and the geocentric model.

Question 3

A 'solar-scope' is a device that can allow safe viewing of the Sun. It is pointed at the Sun and an image is formed on a screen. A simplified diagram is shown in Figure 1. The sections labelled 1 and 2 are where a lens or mirror might be located.

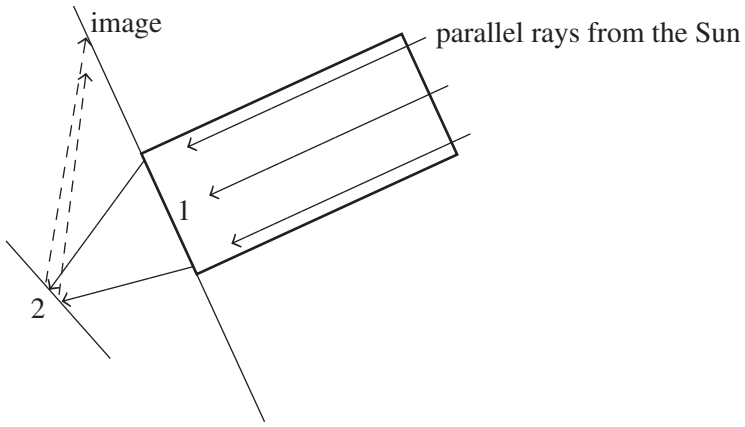

Figure 1

Which of the following most likely identifies what is found at sections 1 and 2?

	1	2
A.	lens	lens
B.	lens	mirror
C.	mirror	mirror
D.	mirror	lens

Use the following information to answer Questions 4 and 5.

The orbital motions of some of the outer solar system planets are shown in Figure 2. These are not drawn to scale. The radii of the orbits are in astronomical units (AU) and originate from the centre of the solar system (the Sun is not shown). For these questions Pluto should be considered a planet; it is the one shown the furthest from the Sun.

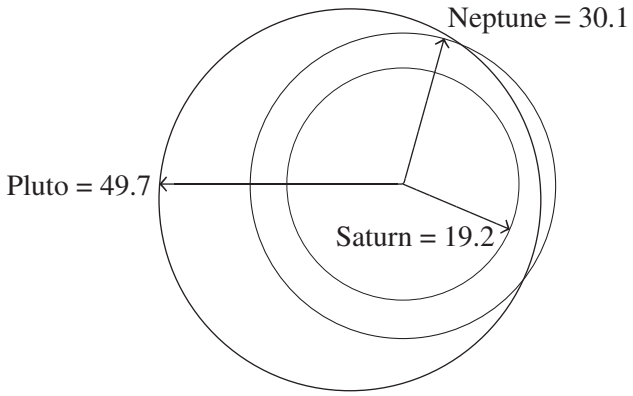

Figure 2

Question 4

At its closest, Pluto is approximately 29.7 AU from the Sun, and at its furthest, 49.7 AU from the Sun. The speed of light is 3×10^8 m s^{-1} and 1 AU = 1.5×10^{11} m.

The time difference it takes for sunlight to reach Pluto between its closest and furthest approach to the Sun is closest to

A. 7 h
B. 3 h
C. 4 h
D. 10 h

Question 5

The shape of Pluto's orbit is best described as

A. a circle.
B. an epicycle.
C. an ellipse.
D. an ecliptic.

Use the following information to answer Questions 6 and 7.

If a plot of the Sun's position against background stars is drawn, it would look roughly like that shown in Figure 3. The maximum and minimum points on the path would occur at +23.5 and –23.5 degrees. The measurements are taken at the celestial equator.

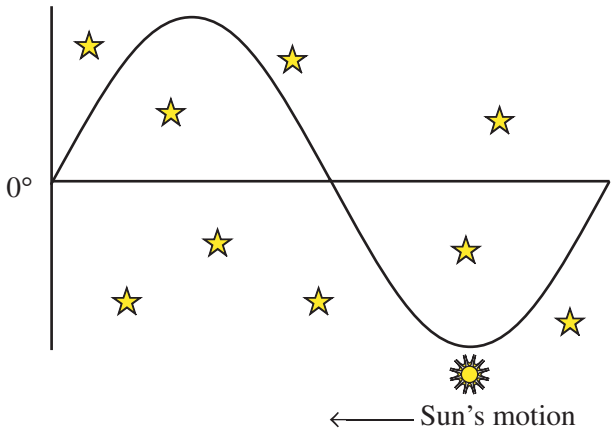

Figure 3

Question 6

What type of motion of the Sun around Earth does the shape of the graph in Figure 3 indicate?

A. its diurnal motion
B. its monthly motion
C. its quarter-yearly motion
D. its annual motion

Question 7

The 0° (horizontal) line is best known as the

A. North Pole.
B. great epicycle.
C. elliptic.
D. ecliptic.

Use the following information to answer Questions 8 and 9.

On 23 September, at midnight, a star is spotted at the zenith in the Melbourne sky. (Melbourne's latitude is 37.8136° S and its longitude is 144.9631° E.)

Question 8

The star mentioned above would have a declination of

A. 0°
B. 90°
C. –38°
D. –52°

Question 9

One hour later, the star would have moved an equivalent of how many degrees of an arc from the zenith?

A. 0°
B. 15°
C. 45°
D. 90°

Use the following information to answer Questions 10 and 11.

Attenuation is the loss of signal as radio waves pass through a medium. An example of one such medium is the atmosphere of Earth.

Figure 4 below shows a graph of attenuation (dB km^{-1}) versus frequency (GHz) in the atmosphere for two gas molecules, water (H_2O) and oxygen (O_2).

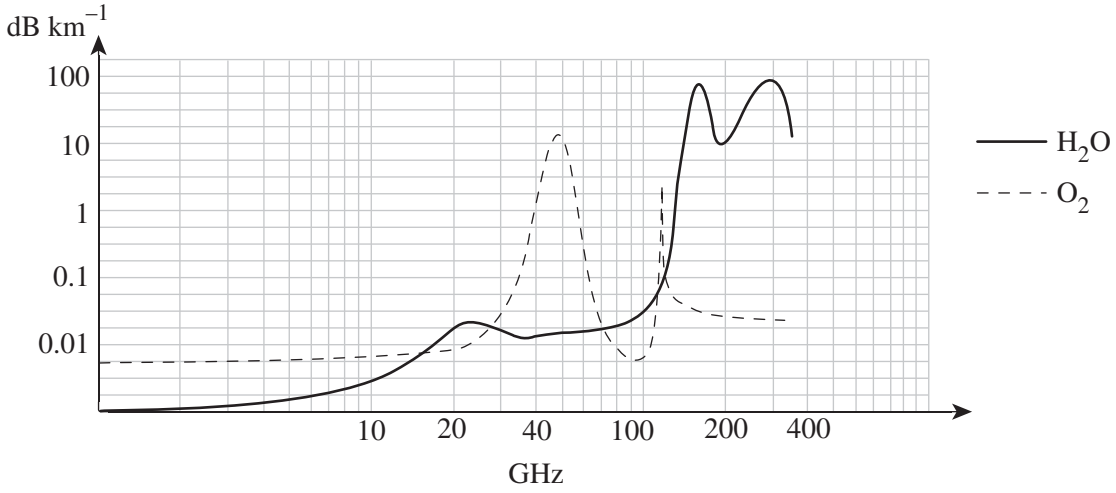

Figure 4

Question 10

The maximum loss of signal for oxygen and water, respectively, occurs at approximate frequencies of

A. 50×10^9 and 300×10^9 Hz.

B. 50×10^6 and 300×10^6 Hz.

C. 300×10^9 and 50×10^9 Hz.

D. 300×10^6 and 50×10^6 Hz.

Question 11

The Atacama Large Millimeter/submillimeter Array (ALMA) is located in the Atacama Desert of northern Chile. It consists of 66 radio telescopes that operate at an altitude of 5000 metres.

The high altitude and dryness improves the images obtained in the millimetre range because attenuation is

A. increased, due to fewer water molecules being present.

B. increased, due to more water molecules being present.

C. reduced, due to fewer water molecules being present.

D. reduced, due to more water molecules being present.

SECTION B

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You should take the value of g to be 10 m s^{-2}.

Detailed study 2 – Astrophysics

Question 1

Shortly after the Big Bang, when only hydrogen was present, there was a period when the temperature and density of the universe was just high enough for new atoms to be formed.

During this period

A. all other elements were formed.
B. elements lighter than iron were formed.
C. elements heavier than iron were formed.
D. helium was formed from hydrogen.

Question 2

Stars are thought to be the source of many of the elements heavier than hydrogen.

The process that leads to the formation of these elements in stars also leads to the

A. release of energy.
B. fission of heavy elements.
C. increase of mass of a star.
D. release of neutrons.

Question 3

Most stars can be found on the main sequence of the Hertzsprung–Russell diagram.

Main-sequence stars with a high absolute magnitude would also have

A. a high temperature.
B. a high mass.
C. a short lifespan.
D. all of the above

Question 4

A star with a surface temperature of about 5500 K would appear

A. blue.
B. red.
C. yellow.
D. white.

Question 5

As stars grow older, they move across the Herztsprung–Russell diagram

A. along the main sequence towards cooler stars.
B. away from the main sequence towards cooler stars.
C. towards the main sequence.
D. away from the main sequence towards hotter stars.

Question 6

The table below shows data for three stars, A, B and C, that have the same luminosity.

Star	Distance (ly)	Apparent brightness
A	4	*Y*
B	12	4
C	*X*	1

Which of the following shows the correct values for *X* and *Y*?

	X	*Y*
A.	6	36
B.	12	9
C.	12	36
D.	24	36

Question 7

At the end of their lives, stars sometimes form a planetary nebula, as shown in Figure 1.

Figure 1

The visible star found at the centre of such a nebula could be a

A. red giant star.
B. black hole.
C. main-sequence star.
D. white dwarf star.

Question 8

A galaxy is photographed using a powerful telescope. Its appearance is linear with a bulging centre, as shown in Figure 2.

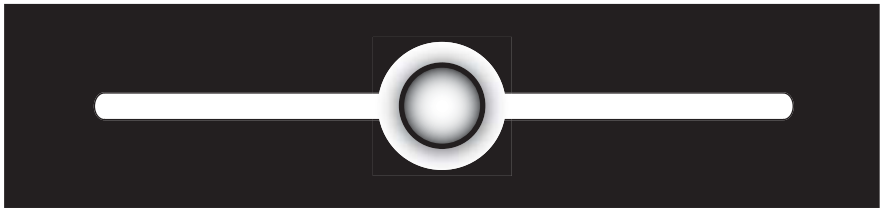

Figure 2

Which of the following galaxy types would be compatible with this observation?

A. elliptical and barred spiral
B. spiral and barred spiral
C. irregular and elliptical
D. spiral and irregular

Question 9

Galaxies were formed in the early universe by the action of

A. strong nuclear forces.
B. weak nuclear forces.
C. gravitational forces.
D. electromagnetic forces.

Question 10

The sun produces about 3.8×10^{26} W of power by converting mass into energy.

How much mass is lost every second as a result of this process?

A. only a few grams
B. 4.2×10^{9} kg s^{-1}
C. 1.2×10^{18} kg s^{-1}
D. 0 kg s^{-1}

Question 11

Which of the following are all units of astronomical distance?

A. astronomical unit, light year, parsec
B. absolute magnitude, light year, parsec
C. astronomical unit, light year, nanometre
D. Hubble's constant, light year, parsec

SECTION B

Instructions for Section B

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You should take the value of g to be 10 m s^{-2}.

Detailed study 3 – Energy from the nucleus

Question 1

Figure 1 is a simplified diagram of a hydrogen atom. Protons are thought to be made of three fundamental particles called quarks, which are held together by 'gluons', a force which operates at distances less than 10^{-15} m.

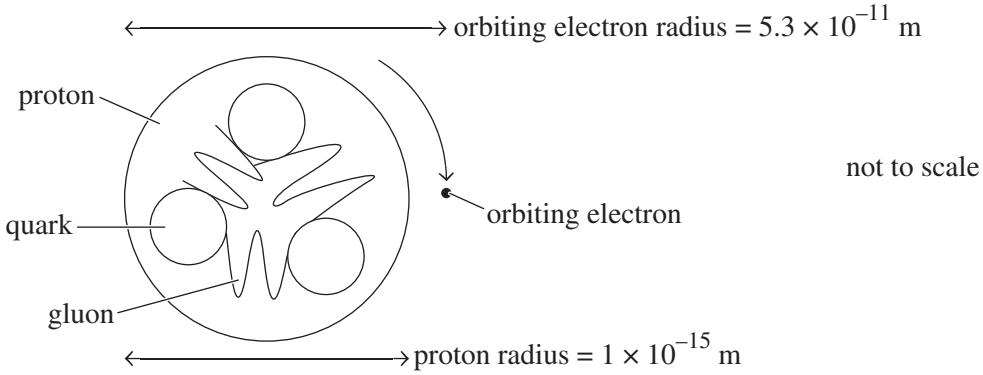

Figure 1

There are four fundamental forces which can act on a hydrogen atom.

Of these four, the force which holds the quarks together is most likely to be the

A. electrostatic force.
B. gravitational force.
C. strong nuclear force.
D. weak nuclear force.

Question 2

In 1989, two scientists claimed that it was possible to conduct 'cold fusion'; that is, fusion at room temperature (25°C) rather than at the very high temperatures found in the Sun. They suggested that a metal called palladium could be added to water; the palladium could then absorb vast amounts of hydrogen atoms and thus force them together to start a fusion reaction. Unfortunately the experiment did not work.

The most likely cause for the experiment not working would be

A. the strength of gravity on Earth is too weak to bring the atoms together.
B. there were not enough hydrogen atoms present for fusion to occur.
C. the hydrogen found in stars is different to the hydrogen found on Earth.
D. the temperature was too low to overcome the electrostatic repulsion between atoms.

Question 3

Theoretically, a fusion reaction takes two protons and two neutrons to form one helium atom. This can be summarised by the following equation:

$$2 \times {}^{1}_{1}\mathrm{H} + 2 \times {}^{1}_{0}\mathrm{n} \rightarrow {}^{4}_{2}\mathrm{He}$$

The mass of a proton is 1.67262×10^{-27} kg, the mass of the neutron is 1.67492×10^{-27} kg and the mass of the helium atom is 6.64466×10^{-27} kg.

The percentage of a proton which is converted to energy is closest to

A. 0.05%
B. 1.0%
C. 1.5%
D. 3.0%

Question 4

Figure 2 shows three distinct nuclear reactions involving nuclei. The size shown is not a true representation of the actual size of the nuclei – they may have a small or large mass number.

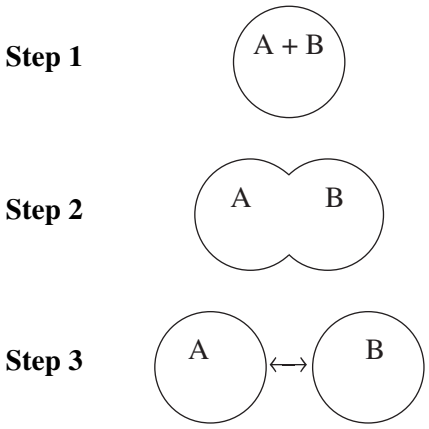

Figure 2

In step 1, nuclei A and B are one nucleus. In step 2, nuclei A and B are either in the process of joining together or separating. In step 3, nuclei A and B are separate and may be approaching or moving away from each other. The sequence of steps for a reaction can either be $1 \rightarrow 2 \rightarrow 3$ or $3 \rightarrow 2 \rightarrow 1$.

Which of the following options best describes the nuclear reactions taking place?

A. Step sequence $1 \rightarrow 2 \rightarrow 3$ is fission and step sequence $3 \rightarrow 2 \rightarrow 1$ is fusion.

B. Step sequence $1 \rightarrow 2 \rightarrow 3$ is fission and step sequence $3 \rightarrow 2 \rightarrow$ is also fission.

C. Step sequence $1 \rightarrow 2 \rightarrow 3$ is fusion and step sequence $3 \rightarrow 2 \rightarrow$ is fission.

D. Step sequence $1 \rightarrow 2 \rightarrow 3$ is fusion and step sequence $3 \rightarrow 2 \rightarrow$ is also fusion.

Question 5

A typical fission reaction uses neutrons to cause the nucleus to become unstable and break apart. An alpha particle is approximately four times larger than a neutron.

What is the main reason that alpha particles are not used, given that they are larger and more likely to hit the target nucleus?

A. The alpha particle and nucleus are both negatively charged, so they naturally want to repel each other.

B. It is much harder to generate alpha particles when compared to neutrons.

C. The alpha particles travel too slowly to initiate fission.

D. The alpha particle and nucleus are both positively charged, so they naturally want to repel each other.

Question 6

A toroid (doughnut)-shaped reactor has been the most successful in creating and sustaining artificial fusion reactions, albeit for a short period of time. The temperatures of the hydrogen plasma (positively and negatively charged ionised gas) are in the tens of millions of degrees, and the plasma is kept inside the toroid by very strong magnetic fields.

It is necessary to ensure the plasma avoids touching the containment walls because it could

A. undergo fusion with the wall materials and destroy the reactor.

B. melt the walls and destroy the reactor.

C. undergo fission with the wall materials and destroy the reactor.

D. transmutate the hydrogen into helium and stop the fusion process.

Use the following information to answer Questions 7–11.

1. A typical fission reaction involving uranium-235 (U-235) is as follows:

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{92}_{36}\text{Kr} + ^{141}_{56}\text{Ba} + X^{1}_{0}\text{n} + E$$

2. The fission of one atom of U-235 generates approximately 202.5 MeV (megaelectron-volts) of energy. (1 eV = 1.6×10^{-19} J)

3. Nuclei that contain even mass numbers are less likely to undergo fission.

Question 7

In the reaction shown above, *X* represents the number of neutrons produced.

This number is

A. 1
B. 2
C. 3
D. 4

Question 8

The energy (*E*) in the reaction shown above is mainly given off in the form of which type of radiation? (Ignore heat energy.)

A. γ-ray
B. β-particle
C. α-particle
D. neutron

Question 9

Which of the following best describes the interactions between the neutrons produced and other U-235 nuclei if the neutrons have high kinetic energies?

A. The U-235 nucleus does not need a neutron to produce a fission reaction.
B. The high kinetic energy makes it easy for another U-235 nucleus to capture one of these neutrons.
C. The high kinetic energy makes it difficult for another U-235 nucleus to capture one of these neutrons.
D. The high kinetic energy makes no difference for another U-235 nucleus to capture one of these neutrons.

Question 10

If 10 W of power was needed, how many U-235 atoms would be required to undergo fission per second? (Assume 100% efficiency of the reaction [that is, all of the 202.5 MeV of energy produced], 1 eV = 1.6×10^{-19} J and $c = 3.0 \times 10^{8}$ m s^{-1}.)

A. 202.5×10^{6}
B. 9.0×10^{16}
C. 6.3×10^{19}
D. 3.1×10^{11}

Question 11

In nuclear reactors, high levels of the isotope U-238 are unwanted and more U-235 is preferred.

One reason that this might be the case is that U-238

A. prefers to undergo fusion with another U-238 atom.

B. reacts chemically with the daughter nuclei produced by fission of other isotopes of uranium.

C. is more stable than U-235 and less likely to undergo fission.

D. reacts chemically with other isotopes of uranium, preventing them from undergoing fission.

SECTION B

Instructions for Section B

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You should take the value of g to be 10 m s^{-2}.

Detailed study 4 – Investigations: Flight

Use the following information to answer Questions 1–4.

Figure 1 shows a solid object in a wind tunnel. The object has a square surface area facing the air movement. The arrows show the direction of movement of the air inside the tunnel.

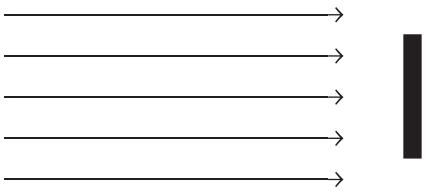
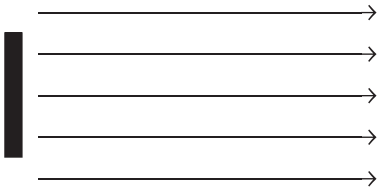


Figure 1

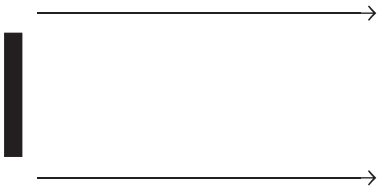
Question 1

Which of the following best represents what happens to the air behind the object in Figure 1?

A.

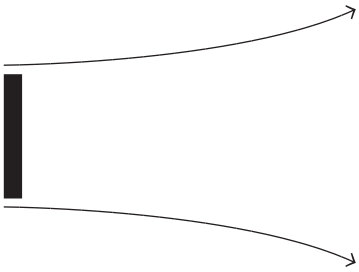


B.



C.

D.



Question 2

The object experiences a drag force as a result of the air flow.

Which of the following would be the most important drag force in this situation?

A. pressure drag
B. skin drag
C. friction drag
D. All forms of drag would be equally important.

Question 3

There are changes to the air pressure around the object as a result of the air flow.

Which of the following is correct?

A. There is smaller pressure in front of the object compared to the area behind the object.
B. There is greater pressure in front of the object compared to the area behind the object.
C. There is smaller pressure above the object compared to the area behind the object.
D. There is smaller pressure below the object compared to the area behind the object.

Question 4

Students working with the wind tunnel now change the shape of the object and, using streamers, achieve the pattern shown in Figure 2. X marks the position of the new object.

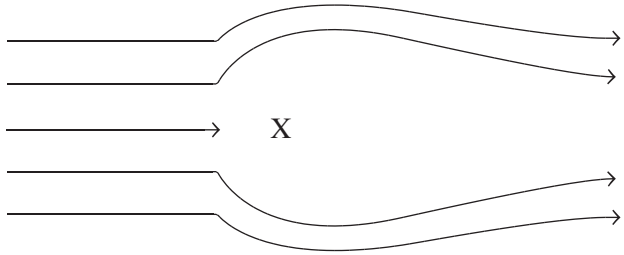
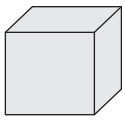
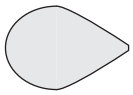
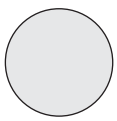


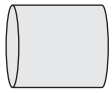
Figure 2

Which of the following is most likely to be the object in position X?

A.


B.


C.


D.


Question 5

The lift force produced by the wing of a modern aircraft can be explained by which of the following physics principles?

A. Bernoulli's principle
B. conservation of momentum
C. Newton's third law of motion
D. all of the above

Question 6

An aircraft flies at a cruising (uniform) speed of 600 km h^{-1}. Its engines provide 2×10^3 N of thrust during this time.

What is the power produced by the aircraft during this time?

A. 0. 3 W

B. 12 W

C. 3.3×10^5 W

D. 1.2×10^6 W

Question 7

An aircraft's wing uses flaps during landing and turning. Lifting a flap on the wing increases drag on it and reduces lift.

Which of the following motions would result when a wing flap is lifted?

A. roll and yaw

B. pitch and roll

C. pitch and yaw

D. roll and pitch

Question 8

A wing-mounted jet engine provides 40 000 N of thrust and is 15 m from the length axis of the plane.

The torque provided by this engine on the plane is

A. 6×10^5 N

B. 6×10^5 N m^{-1}

C. 6×10^5 Nm

D. 6×10^5 mN^{-1}

Question 9

Miniature drones usually have four propellers. These are labelled K to O in Figure 3 below.

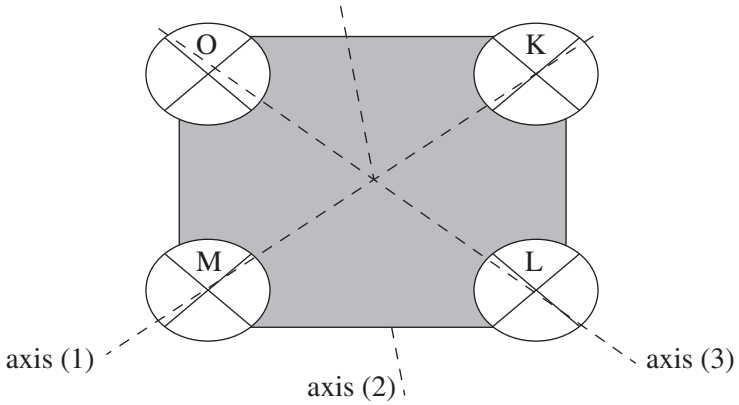


Figure 3

If propeller L should fail during flight, what would be the most likely outcome and why?

A. The drone would crash because it has too little power to stay in the air.

B. The drone would crash because it would become unbalanced and start to rotate around its axis of symmetry (1).

C. The drone would crash because it would become unbalanced and start to rotate around its axis of symmetry (2).

D. The drone would crash because it would become unbalanced and start to rotate around its axis of symmetry (3).

Question 10

When a plane is flying high in the sky without changing altitude, it is subject to two pairs of opposing forces. These are

A. weight/thrust and drag/lift.

B. weight/lift and drag/thrust.

C. weight/normal force and drag/friction.

D. weight/drag and lift/thrust.

Question 11

Figure 4 shows the wing profile of an aircraft in flight.

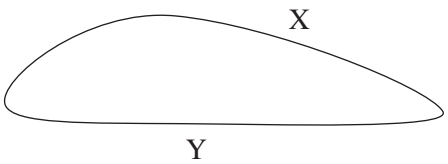


Figure 4

According to Bernoulli's principle, area

A. X would have higher air speeds and higher pressure than area Y.

B. Y would have higher air speeds and higher pressure than area X.

C. X would have higher air speeds and lower pressure than area Y.

D. Y would have higher air speeds and lower pressure than area X.

SECTION B

Instructions for Section B

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Detailed study 5 – Investigations: Sustainable energy sources

Use the following information to answer Questions 1 and 2.

A domestic solar hot water system is rated as being 60% efficient. On a sunny day the system receives 650 W m^{-2} of solar energy.

Question 1

How much energy is converted to the water by the system in one second?

A. 390 J

B. 390 W m^{-2}

C. 390 J m^{-2}

D. 390 J s^{-2}

Question 2

Mary, a homeowner, is considering replacing an electric water heater with a system like the one described above.

What would be the advantage of this change for Mary?

A. The solar system is more efficient.

B. The running cost of the solar system would be less.

C. The heat from the solar system is of a higher quality.

D. The solar system runs more quietly.

Question 3

Solar energy is considered 'renewable' because

A. the energy output from the Sun will not lessen over time.

B. the use of solar energy is not harmful to the environment.

C. solar energy is freely available.

D. solar energy is available throughout the world.

Question 4

The energy harvested by a wind farm is essentially a form of kinetic energy.

If wind speed increases from 20 m s^{-1} to 40 m s^{-1}, the amount of energy contained in the wind will increase by a factor of

A. 1
B. 0.2
C. 2
D. 4

Use the following information to answer Questions 5–9.

An innovative farmer wants to design a system that will allow him to use the energy from a small waterfall on his property to produce electricity. The waterfall is 3 m high and water flows at an average rate of 1500 kg s^{-1}.

Question 5

What is the maximum amount of power the farmer can extract from his waterfall?

A. 50 W
B. 500 W
C. 45 kW
D. 45 000 kW

Question 6

Which of the following is **not** a reason why the farmer will be unable to extract the maximum available energy from the waterfall?

A. Not all of the kinetic energy from the waterfall can be extracted.
B. Not all of the potential energy from the waterfall can be extracted.
C. The water is likely to be too cold and would hold little heat energy.
D. There will be energy lost to the atmosphere throughout such an energy system.

Question 7

The farmer already owns a generator.

What does he need next to build his system?

A. a transformer
B. a battery
C. a water turbine
D. an AC/DC rectifier

Question 8

Consider the following statements regarding the farmer's design:

1. The system is sustainable because it will provide free energy.
2. The system is unsustainable because it will not produce energy in times of drought.

Which of the above statements is/are correct?

A. statement 1 only
B. statement 2 only
C. both statements 1 and 2
D. neither statements 1 nor 2

Question 9

Due to a drought, the flow in the waterfall is reduced to 500 kg s^{-1}.

This means that the output of electricity from the system will be

A. reduced to one-third of the original output.
B. reduced to slightly less than one-third of the original output.
C. reduced to slightly more than one-third of the original output.
D. increased to three times the original output.

Question 10

A Sankey diagram shows how much of the energy put into a device is used productively. Figure 1 shows one such diagram for a power station.

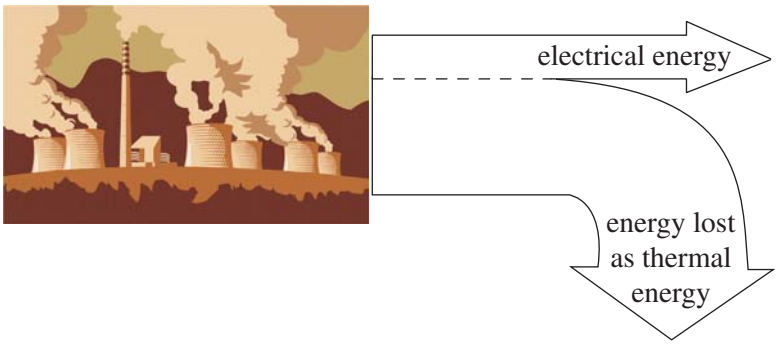

Figure 1

It is possible to conclude from Figure 1 that

A. the power station is less than 50% efficient.
B. only a small amount of the available energy is converted to waste heat.
C. the power station produces a lot of pollution.
D. all of the above

Question 11

Victoria's total average energy requirement for electricity is about 5 GW.

How many kiloWatt-hours does the state of Victoria use in one average day?

A. 60×10^6
B. 120×10^6
C. 216×10^9
D. 432×10^9

SECTION B

Instructions for Section B

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Detailed study 6 – Medical physics

Question 1

Each of the following are key components used in different scanning techniques.

Component 1	strong magnets
Component 2	piezoelectric crystal
Component 3	electrons
Component 4	positive electrons

Which of the following options correctly matches the components with the technique they are used in?

	Component 1	Component 2	Component 3	Component 4
A.	ultrasound	MRI	PET	X-ray
B.	MRI	ultrasound	X-ray	PET
C.	PET	X-ray	ultrasound	MRI
D.	MRI	X-ray	PET	ultrasound

Question 2

Phosphorous-32 (P-32) has a number of uses in medical diagnosis. One example is its use in tagging molecules in DNA, which can then be detected from outside the body.

In order to make use of P-32, it most likely needs to have

A. an unstable inner-shell electron orbital.

B. a stable inner-shell electron orbital.

C. a stable nucleus.

D. an unstable nucleus.

Use the following information to answer Questions 3 and 4.

When X-rays are being used they can interact with the body principally in three ways. These are shown in Figure 1.

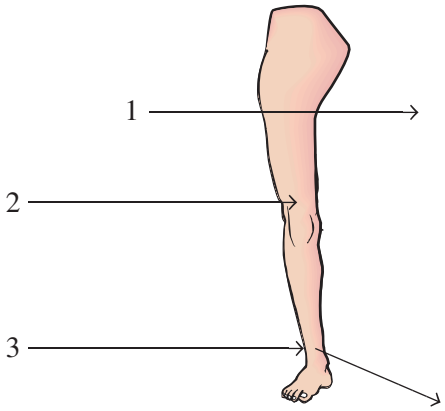

Figure 1

Question 3

The ray that would be most useful in radio-imaging (that is, it would reach a detector) is ray

A. 1
B. 2
C. 3
D. none of the above

Question 4

The ray that would be most useful in radio-therapy (for example, treating a tumour) is ray

A. 1
B. 2
C. 3
D. none of the above

Use the following information to answer Questions 5 and 6.

Figure 2 shows a cross-section of a typical fibre-optic endoscope. Three channels are labelled with their function.

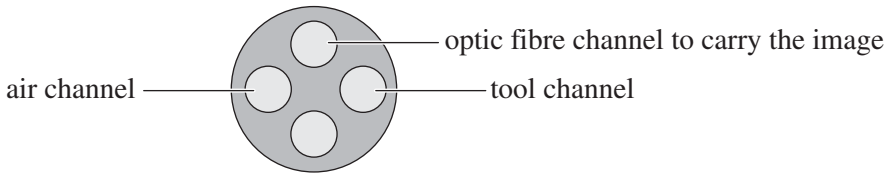

Figure 2

Question 5

The fourth channel in Figure 2 could be used as

A. a spare channel.
B. an optic-fibre channel to provide a high-powered laser cutter.
C. an optic-fibre channel to provide illumination of the site.
D. a body-fluid channel to carry away blood.

Question 6

One use of the air channel could be to

A. provide a patient with oxygen during an operation.
B. remove air from an operation site.
C. provide a high-powered air cutter.
D. 'inflate' an operation site to give the surgeon room to move.

Question 7

Figure 3 shows a thin, flexible glass 'tube' which can transmit light. An endoscope is made up of many of these.

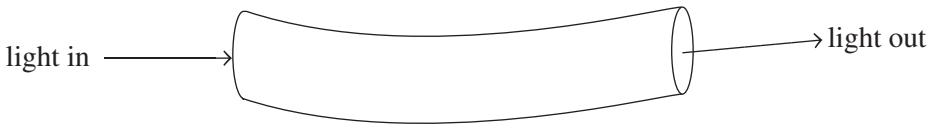

Figure 3

The ability of the light to 'follow the curves' within the fibre optic depends on total internal

A. reflection.
B. refraction.
C. diffraction.
D. polarisation.

Question 8

Figure 4 below shows two graphs – one measuring a normal, healthy bone, and one where the bone has become more brittle (due to osteoporosis).

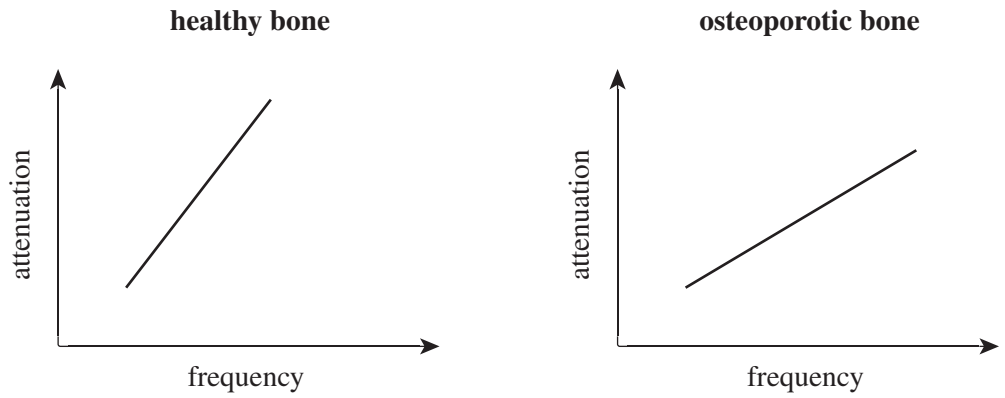

Figure 4

Which imaging technique is most likely to have been used to obtain the information shown in the graphs in Figure 4?

A. PET
B. ultrasound
C. MRI
D. CT

Question 9

The cornea is a clear part of the eye that is required for vision. Sometimes the shape of the cornea can be changed to help improve vision and reduce the need for glasses. The cornea is 'flattened' by a medical device rather than by surgery (cutting).

The medical device most likely used for this procedure is

A. X-ray light.
B. laser light.
C. ultrasound waves.
D. ultra-bright fluorescent light.

Question 10

The characteristics of some imaging-technique options are listed in the table below.

	Option 1	**Option 2**	**Option 3**
Cost of machine	middle	highest	lowest
Imaging of soft tissue (abdomen)	excellent	good	poor
Imaging of hard tissue (bone)	poor	good	very good

Which of the following most likely identifies these three different imaging techniques?

	Option 1	**Option 2**	**Option 3**
A.	ultrasound	X-rays	CAT scans
B.	CAT scans	ultrasound	X-rays
C.	CAT scans	X-rays	ultrasound
D.	ultrasound	CAT scans	X-rays

Question 11

A typical frequency used in ultrasound is 1.5 MHz, whereas a red laser light source has a wavelength of 667 nm (nanometres). (The speed of light $c = 3 \times 10^8$ m s^{-1}.)

What is the ratio of frequency of sound to frequency of red laser closest to?

A. $1.5 \times 10^6 : 3 \times 10^{14}$

B. $1 : 3 \times 10^{14}$

C. $1 : 3 \times 10^8$

D. $1 : 3 \times 10^{-8}$

END OF QUESTION AND ANSWER BOOKLET

