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# 2012 Trial Examination

**STUDENT NUMBER**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Figures | | | | | | | | | Letter |
| Words | | | | | | | | | |

# PHYSICS

## Unit 2 – Written examination 2

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

## QUESTION & ANSWER BOOK

**Structure of Book**

| *Section* | *Number of questions to be answered* | *Number of marks* |
|---|---|---|
| **A-Core-Areas of Study** | | |
| 1. Motion | 18 | 38 |
| 2. Wavelike properties of light | 15 | 32 |
| **B. Detailed Studies** | | |
| 1. Astronomy OR | 10 | |
| 2. Astrophysics OR | 10 | |
| 3. Energy from the nucleus OR | 10 | 20 |
| 4. Flight OR | 10 | |
| 5. Sustainable energy sources OR | 10 | |
| 6. Medical physics | 10 | |
| | | Total 90 |

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and rulers, up to 2 pages (A4) of prewritten notes and an approved calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out or liquid/tape.

**Materials supplied**

- Question and answer book of 36 pages (including a multiple choice answer sheet).

**Instructions**

- Print your name in the space provided on the top of this page.
- All written responses must be in English.
- Write your answers in the spaces provided.

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

## SECTION A

**Instructions for Section A**

Answer **all** questions **for both** of the Areas of Study in this section of the paper.
You should take the value of $g$ to be 10 N $kg^{-1}$ and the value of $c$ to be $3\times10^{8}$ $ms^{-1}$.

**Areas of study** **Page**



**SECTION A –** continued

## Area of Study 1 – Motion

*The following information applies to Questions 1 to 4.*

Figure 1 shows the velocity time graph for a bike which accelerates from rest at t = 0.
From t = 6 to t = 12 seconds, a constant drag force (air and rolling resistance) acts on the bike, totalling 100 N.
The bike and its rider has a total mass of 90 kg.

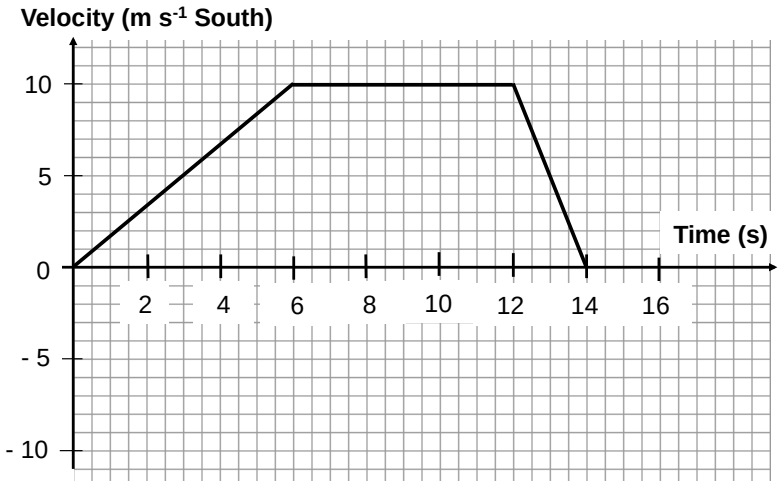


**Figure 1**

### Question 1

Determine the displacement of the bike over the first 12 seconds. State the magnitude, direction and indicate whether the quantity is a **scalar** or **vector** quantity.

| | | |
|---|---|---|
| m | Direction: | SCALAR / VECTOR |

3 marks

**SECTION A – Area of study 1 –** continued
**TURN OVER**

**Question 2**

Determine the average speed over 12 seconds. Also indicate whether the quantity is a **scalar** or **vector** quantity.

| | |
|---|---|
| $m\ s^{-1}$ | SCALAR / VECTOR |

2 marks

**Question 3**

Determine the value of the driving force at t = 10 sec and state the key physics principle that leads you to your answer.

---

N

2 marks

**Question 4**

Determine the magnitude and direction of the acceleration at t = 13 sec.

| | |
|---|---|
| $m\ s^{-2}$ | Direction: |

2 marks

**SECTION A – Area of study 1 –** continued

*The following information applies to Questions 5 to 9.*

Consider a toy rocket sled (mass 400 g) in operation. When ignited the rocket engine expels hot gases at a constant rate for 0.3 sec. A constant sliding friction force of 0.2 N acts on the sled. Figure 2 shows the cart at t = 0.1 sec.

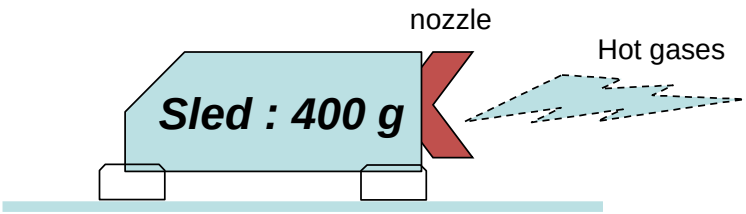


**Figure 2**

**Question 5**

Draw and label key forces acting on the sled. Ensure that relative size is shown where possible.

2 marks

**Question 6**

Describe the effect of the rocket engine on the motion of the sled over 0.5 seconds (ie. Beyond the duration of the burn) according to Galileo and Aristotle.

**Aristotle**

**Galileo**

2 marks

**SECTION A – Area of study 1 –** continued
**TURN OVER**

After 0.3 seconds, the sled (mass 400 g) reaches a speed of 15 m $s^{-1}$.

**Question 7**

Determine the magnitude of the acceleration over the first 0.3 seconds.

m $s^{-2}$

2 marks

**Question 8**

Determine the distance travelled by the sled over the first 0.3 sec.

m

2 marks

**Question 9**

Explain the propulsion of the sled in terms of Newton's Third Law, identifying the appropriate action-reaction pair of forces.

3 marks

*The following information applies to Questions 10 to 15.*

A girl is pushing a 5 kg trolley along a horizontal floor surface, applying a force of 40 N at an angle of 30$^{o}$, as shown in Figure 3. A combined drag force of 10 N acts on the trolley.

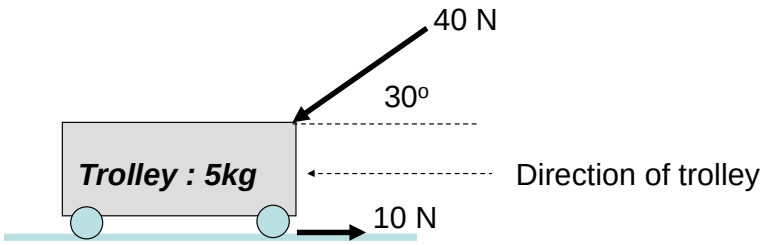


**Figure 3**

**Question 10**

Determine the horizontal component of the 40 N driving force.

N

2 marks

**Question 11**

Determine the net force acting on the trolley.

N

2 marks

**SECTION A – Area of study 1 –** continued
**TURN OVER**

**Question 12**

Determine the acceleration of the trolley.

| |
|---|
| $ms^{-2}$ |

2 marks

**Question 13**

Calculate the work done by the 40 N force over a distance of 5 m.

| |
|---|
| J |

2 marks

**Question 14**

Calculate the kinetic energy of the trolley after 5 m.

| |
|---|
| J |

2 marks

**SECTION A – Area of study 1 –** continued

The girl releases the trolley as it reaches a rougher patch of floor. The trolley stops in a distance of 8 m

**Question 15**

Calculate the power exerted by the total friction forces acting on the trolley.

W

3 marks

*The following information applies to Questions 16 to 18.*

Consider a wooden block sliding from rest down an icy (assume frictionless) inclined plane towards a spring, as shown in Figure 5. The characteristics curve for the spring is shown in Figure 4.
The drop in vertical height for the centre of mass as the block slides to the spring is 0.6 m.
The block has a mass of 2.1 kg.
The spring has an initial length of 0.12 m.
You may assume that the block does not fall significantly as the spring compresses.

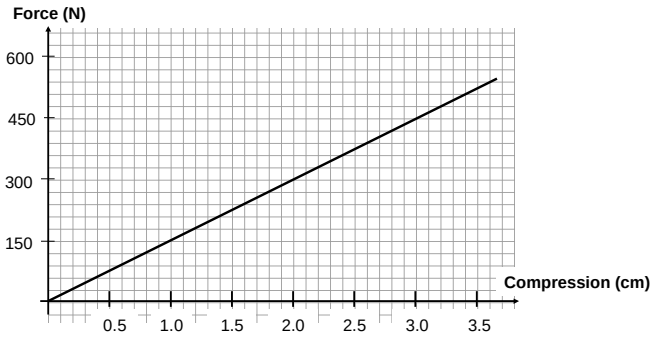


**Figure 4**

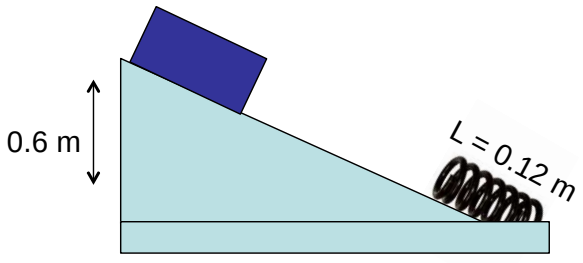


**Figure 5**

**Question 16**

Determine the value of the spring constant, *k*.

| |
|---|
| N $m^{-1}$ |

1 mark

**Question 17**

Determine the speed of the cart prior to impact with the spring.

| |
|---|
| m $s^{-1}$ |

2 marks

**Question 18**

Determine the minimum length of the spring when the block is initially brought to rest

| |
|---|
| m |

2 marks

**END OF AREA OF STUDY 1**
**SECTION A -** continued

## Area of Study 2 – Wavelike Properties of Light

*The following information applies to Questions 1 to 3.*

The displacement-distance characteristics of a transverse wave is shown in Figure 1. The frequency of the source is 450 Hz.

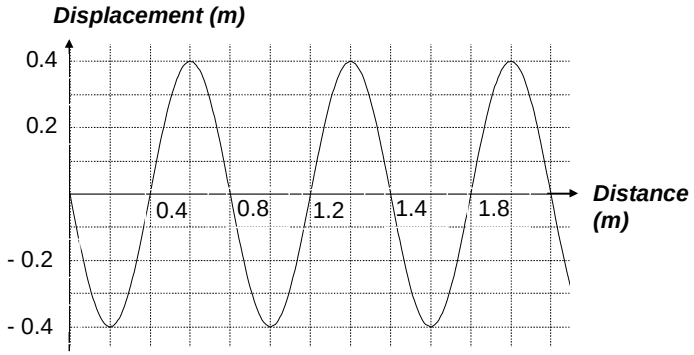


**Figure 1**

### Question 1

State the wavelength and amplitude of the wave.

| $\lambda$ : m | Amplitude: m |
|---|---|

2 marks

### Question 2

Calculate the period of the wave.

s

2 marks

### Question 3

Determine the speed of the wave in the medium.

m $s^{-1}$

2 marks

**SECTION A – Area of study 2 –** continued
**TURN OVER**

*The following information applies to Questions 4 to 6.*

Light from a laser source of wavelength 460 nm travels through an optic fibre of refractive index 1.48.

**Question 4**

Which of the following colours would best match the source? Circle best answer.

YELLOW RED BLUE

1 mark

**Question 5**

Calculate the speed of the light as it travels through the optic fibre.

m $s^{-1}$

2 marks

**Question 6**

Calculate the frequency of the source.

Hz

2 marks

Figure 2 shows light travelling from air and meeting a plastic block with a refractive index of 1.40. Some of the light reflects from the boundary, whilst the remainder refracts.

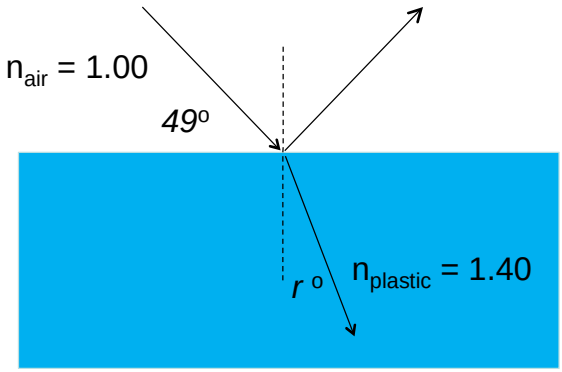


**Figure 2**

**Question 7**

State **and label** the angle of incidence and reflection on Figure 2.

2 marks

**Question 8**

Calculate the angle of refraction.

degrees

2 marks

Figure 3 shows a crude optic fibre, which consists simply of a circular cross-section of glass fibre with a refractive index of 1.49.

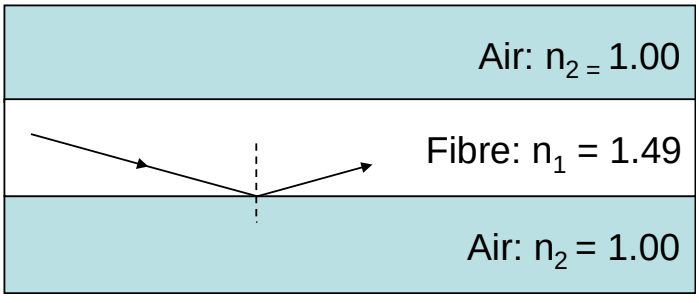


**Figure 3**

**SECTION A – Area of study 2 –** continued
**TURN OVER**

**Question 9**

Determine the critical angle for the fibre.

degrees

2 marks

**Question 10**

Explain the effect on the critical angle if the glass fibre is immersed in water.

3 marks

**Question 11**

Describe why the polarisation of light is clear evidence of the transverse wave model for light. Use a diagram to aid your explanation.

3 marks

**Question 12**

Draw a diagram showing how reflection can be explained using the particle model for light.

2 marks

Figure 4 shows a diagram of waves meeting the boundary between two media of different optical densities.

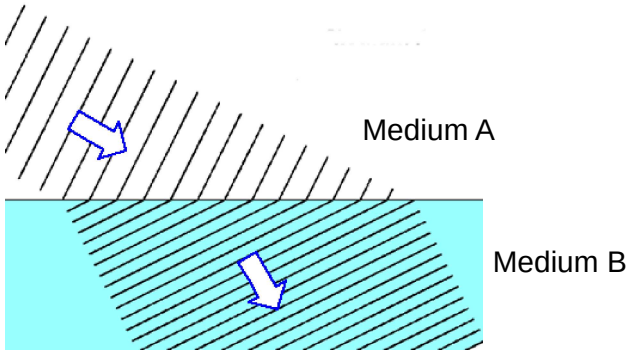


**Figure 4**

**Question 13**

Which medium would you expect to have the higher refractive index? Explain your answer.

3 marks

**SECTION A – Area of study 2 –** continued
**TURN OVER**

**Question 14**

Use your understanding of colour addition of light to complete the gaps below.

RED + GREEN ⇒ _____ 1 mark

CYAN + _____ ⇒ WHITE 1 mark

(1 + 1 = 2 marks)

Figure 5 shows the dispersion of a white light source through a triangular prism.

**Question 15**

Using your understanding of refraction and dispersion, which of the following options best matches the scenario shown in Figure 5?

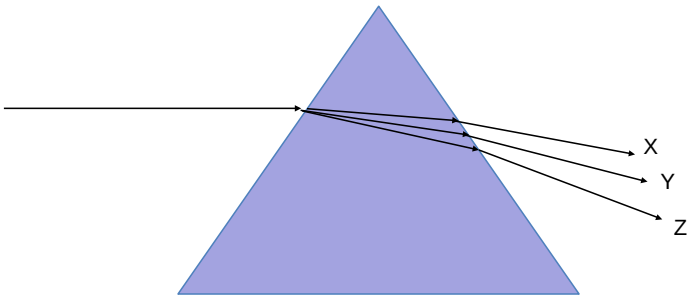


**Figure 5**

| Option | Ray X | Ray Y | Ray Z |
|---|---|---|---|
| **A** | Red | Blue | Green |
| **B** | Green | Blue | Red |
| **C** | Blue | Red | Green |
| **D** | Red | Green | Blue |

2 marks

**END OF SECTION A**

## SECTION B

**Instructions for Section B**

Choose **one** of the following **Detailed Studies**. Answer **all** questions on the Detailed Study you have chosen. You should take the value of $g$ to be 10 N $kg^{-1}$ and the value of $c$ to be $3.0 \times 10^8$ $ms^{-1}$.

There are ten questions for each section. Each question is worth **2 marks.**

**Detailed study** **Page**



 

## Detailed Study 1- Astronomy

### Question 1

Which of the following statements about Ptolemy's model of the Universe is correct?

**A.** The Sun and all the planets moved in perfect circles around the Earth
**B.** The Sun and all the planets orbited the Earth following elliptical paths
**C.** The planets orbited the Earth with perfectly circular orbits
**D.** The planets orbited the Sun with perfectly circular orbits

### Question 2

Which of the following statements was part of Galileo's interpretation of the Universe?

**A.** Observations of the moons of Jupiter suggested that not everything moved in circular orbits, but could be elliptical instead.
**B.** Observations of the moons of Jupiter suggested that not everything revolved directly around the Earth.
**C.** Observations of the moons of Jupiter suggested that it was the centre of the Universe
**D.** Observations of the moons of Jupiter could not be explained using a heliocentric model

*The following information applies to Questions 3 to 6*

To see the brightest star in a particular constellation, David must direct his telescope S $40^o$ E and at an angle of $24^o$ to the nearest point on the horizon.
David is observing the star from a location that has a latitude of $37^o$S

### Question 3

Which of the following is the correct azimuth of the star?

**A.** $50^o$
**B.** $140^o$
**C.** $24^o$
**D.** $114^o$

### Question 4

Which of the following is the correct altitude of the star?

**A.** $24^o$
**B.** $37^o$
**C.** $66^o$
**D.** $40^o$

**Question 5**

Which of the following statements about the apparent motion of the constellation would be correct?

**A.** The stars in the constellation would appear to rotate anticlockwise about a point $37^o$ from the southern horizon.
**B.** The stars in the constellation would appear to rotate clockwise about a point $37^o$ from the southern horizon.
**C.** The stars in the constellation would appear fixed in the sky, $37^o$ from the southern horizon.
**D.** The stars in the constellation would appear fixed in the sky, $24^o$ from the southern horizon.

David now looks directly upwards from his location, effectively making an angle of $90^o$ to all points on the horizon.

**Question 6**

Which point is he now observing?

**A.** The zenith
**B.** The equinox
**C.** The vernal equinox
**D.** The right ascension

**Question 7**

Which of the following best explains the **diurnal motion** of the stars through the sky?

**A.** The annual revolution of the Earth about the Sun
**B.** The daily rotation of the Earth about the Sun
**C.** The daily rotation of the Earth about its own axis
**D.** The rotation of the stars about the centre of the galaxy

**Question 8**

Which of the following best explains the **annual motion** of the stars through the sky?

**A.** The annual revolution of the Earth about the Sun
**B.** The daily rotation of the Earth about its own axis
**C.** The daily rotation of the Sun about its own axis
**D.** The rotation of the stars about the centre of the galaxy

**Question 9**

Which of the following best describes one advantage of the Newtonian telescope?

**A.** It is not subject to chromatic aberration as it uses mirrors instead of lenses in its design.
**B.** It is not subject to spherical aberration as it uses mirrors instead of lenses in its design.
**C.** It is not subject to chromatic aberration as it uses lenses instead of mirrors in its design.
**D.** It is not subject to spherical aberration as it uses lenses instead of mirrors in its design.

**Question 10**

Which of the following would indicate the brightest star when viewed from the equator?

**A.** Apparent Magnitude: 4.0, Absolute Magnitude: 2.3
**B.** Apparent Magnitude: -2.0, Absolute Magnitude: 4.3
**C.** Apparent Magnitude: 0.3, Absolute Magnitude: -3.3
**D.** Apparent Magnitude: 8.0, Absolute Magnitude: -5.3

**END OF DETAILED STUDY 1**
**SECTION B -** continued

## Detailed Study 2 - Astrophysics

### Question 1

How would you expect to classify a star which has a luminosity of $1 \times 10^{-4}$ of the Sun and a surface temperature of $2 \times 10^{4}$ K?

**A.** Red Giant
**B.** Blue Giant
**C.** White Dwarf
**D.** Red Dwarf

### Question 2

Which of the following best compares the properties of red giants and white dwarf stars?

**A.** Red giants are more luminous because they are much hotter than white dwarf stars
**B.** White dwarf stars are more luminous because they are much hotter than red giants.
**C.** Red giants are more luminous because they are much larger than white dwarf stars
**D.** Red giants are more luminous because they are much closer than white dwarf stars

### Question 3

Which of the following is a possible subsequent state for a star the same size as our Sun?

**A.** Supernova
**B.** Neutron star
**C.** Black hole
**D.** White dwarf

### Question 4

Which of the following fusion reactions would you expect to be taking place in a red supergiant?

**A.** Carbon $\rightarrow$ Oxygen
**B.** Hydrogen $\rightarrow$ Helium
**C.** Iron $\rightarrow$ Boron
**D.** No fusion is occurring, the star is cooling down.

**Question 5**

Which of the following best describes the type of galaxy shown below (Image: NASA)

**A.** Spiral
**B.** Barred spiral
**C.** Eliptical
**D.** Irregular

**Question 6**

Assuming the galaxy shown above is similar in size to the Milky Way, which of the following statements best summarises its likely size and contents?
**A.** Diameter: 10,000 light years. Contains: 2 billion stars
**B.** Diameter: 100 light years. Contains: 200 billion stars
**C.** Diameter: 100,000 light years. Contains: 200 million stars
**D.** Diameter: 100,000 light years. Contains: 200 billion stars

*The following information applies to Questions 7 & 8*

Figure 1 shows a chart of data similar to that collected by Edwin Hubble.

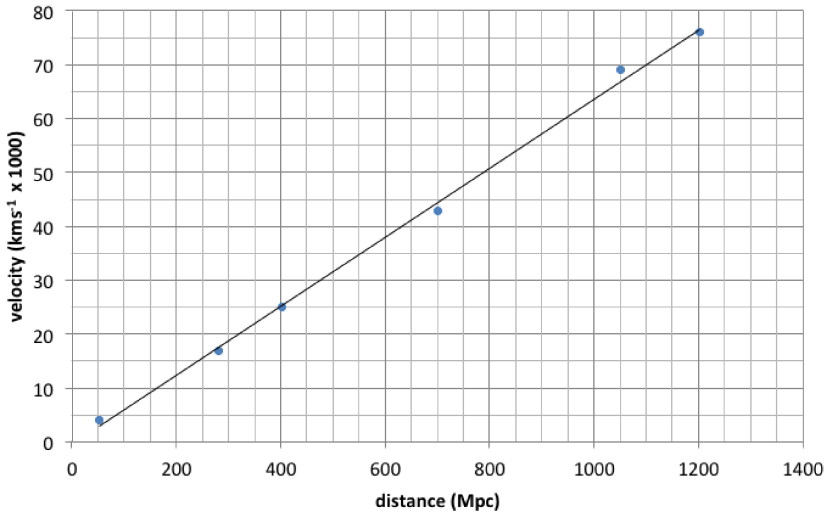


**Figure 1**

**SECTION B – Detailed study 2** – continued
**TURN OVER**

**Question 7**

Which of the following inferences concerning this data is correct?

**A.** The strong positive correlation between the distance to a galaxy and its recessional velocity clearly indicates that the Universe is in steady state and is not expanding.
**B.** The strong positive correlation between the distance to a galaxy and its recessional velocity can be used to estimate the age of the universe.
**C.** The strong positive correlation clearly violates the Big Bang Theory.
**D.** The strong positive correlation between the distance to a galaxy and its recessional velocity clearly indicates that the universe is moving at a constant speed.

**Question 8**

Which of the following statements concerning the data presented in Figure 1 is correct?

**A.** The data indicates that some of the galaxies plotted would be "red-shifted", with more distant data points experiencing more red shift and closer galaxies "blue-shift".
**B.** The data indicates that all of the galaxies plotted would be "red-shifted", with more distant data points experiencing more red shift.
**C.** The data indicates that all of the galaxies plotted would be "red-shifted", with closer data points experiencing more red shift.
**D.** The data indicates that some of the galaxies plotted would be "red-shifted", but the extent of red shift is not related to the relative distant from the observer.

Using the parallax method of stellar observation, an astronomer calculates a star to be $1.9 \times 10^{14}$ km from Earth.

**Question 9**

Which of the following is the best approximation for the distance to the star in parsecs?

**A.** 5.9 pc
**B.** 6.2 pc
**C.** 3.1 pc
**D.** 1.9 pc

**Question 10**

Which of the following is the best estimate for the parallax angle in arcseconds, using a baseline of 1 AU?

**A.** 0.16 arcseconds
**B.** 0.17 arcseconds
**C.** 0.32 arcseconds
**D.** 0.53 arcseconds

**END OF DETAILED STUDY 2**
**SECTION B -** continued
**TURN OVER**

## Detailed Study 3 – Energy from the nucleus

### Question 1

Which of the following forces acts over very short distances and is responsible for binding nucleons within an atom?

**A.** Electrostatic force
**B.** Weak nuclear force
**C.** Gravitational force
**D.** Strong nuclear force

### Question 2

Which of the following statements concerning the reaction of two hydrogen nuclei into helium is correct?

**A.** The process is fusion: the mass of the two free hydrogen nuclei is greater than the mass of the helium nuclei is greater than the mass of the products, with the balance converted to energy.
**B.** The process is fission: the mass of the two free hydrogen nuclei is greater than the mass of the helium nuclei is less than the mass of the products, with the balance converted to energy.
**C.** The process is fusion: the mass of the two free hydrogen nuclei is greater than the mass of the helium nuclei is less than the mass of the products, with the balance converted to more matter.
**D.** The process is fission: the mass of the two free hydrogen nuclei is greater than the mass of the helium nuclei is greater than the mass of the products, with the balance converted to more matter.

### Question 3

Which of the following elements would not be expected to undergo nuclear fusion?

**A.** ${}^{7}_{3}Li$
**B.** ${}^{4}_{2}He$
**C.** ${}^{16}_{8}O$
**D.** ${}^{235}_{92}U$

*The following information applies to Questions 4 to 9*

One possible fission reaction of enriched U-235 is shown below. 215 MeV of energy is released in the process.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{144}_{56}Ba + ^{X}_{36}Kr + 2^{1}_{0}n + energy$$

**Question 4**

Which of the following best compares the properties of the free neutrons in the reaction above?

**A.** The single neutron that initiates the reaction is a slow (or thermal) neutron that can be absorbed by U-235. The products are also slow neutrons that must be accelerated for subsequent fission.

**B.** The single neutron that initiates the reaction is a slow (or thermal) neutron that can be absorbed by U-235. The products are slow neutrons that must be absorbed to ensure a chain reaction can take place.

**C.** The single neutron that initiates the reaction is a fast neutron that can be absorbed by U-235. The products are also fast neutrons that must be slowed to ensure a chain reaction can take place.

**D.** The single neutron that initiates the reaction is a slow (or thermal) neutron that can be absorbed by U-235. The products are fast neutrons that must be slowed to ensure a chain reaction can take place.

**Question 5**

The value of X (part of the krypton product) in the equation is equal to

**A.** 90
**B.** 36
**C.** 87
**D.** 89

**Question 6**

Which of the following best approximates the energy released in J?

**A.** 215 J
**B.** $1.34 \times 10^{21}$ J
**C.** $3.44 \times 10^{-11}$ J
**D.** 3.44 J

**Question 7**

Which of the following best approximates the mass defect that would be observed?

**A.** $1.15 \times 10^{-19}$ kg
**B.** $3.82 \times 10^{-28}$ kg
**C.** 3.82 kg
**D.** 3.82 g

**SECTION B – Detailed study 3** – continued
**TURN OVER**

**Question 8**

Which of the following would best describe the type of waste that the krypton and barium would be classified as?

**A.** High level radioactive waste
**B.** Low level radioactive waste
**C.** Stable isotopes used in building products
**D.** Additional fissile products to be reused in the reactor

**Question 9**

Which of the following would best describe the likely **increase** the rate of reaction of the U-235?

**A.** Add cadmium rods into the fuel mix to decrease the absorption of neutrons
**B.** Flatten the U-235 into thin sheets
**C.** Add cadmium rods into the fuel mix to increase the absorption of neutrons
**D.** Use a compact spherical ball of U-235.

**Question 10**

Which of the following describes the purpose of the moderator in a nuclear reactor?

**A.** To slow fast moving neutrons so they can be more readily absorbed.
**B.** To absorb fast moving neutrons.
**C.** To protect workers from excessive heat and radiation from the fission reaction.
**D.** To allow heat from the reaction to convert water to steam to power turbines.

**END OF DETAILED STUDY 3**
**SECTION B -** continued

## Detailed Study 4 - Flight

*The following information applies to Questions 1 & 2.*

A wind tunnel has an initial cross-section of 2.5 $m^2$ and an anemometer records a windspeed of 21 $ms^{-1}$. The air is then directed through a circular duct of diameter 1.2 m.

### Question 1

Which of the following is the best approximation for the flow rate through the tunnel?
**A.** 0.1 $m^3 s^{-1}$
**B.** 8.4 $m^3 s^{-1}$
**C.** 52.5 $m^3 s^{-1}$
**D.** 2.5 $m^3 s^{-1}$

### Question 2

Which of the following is the best approximation for the speed of the flow through the circular duct?
**A.** 38.7 $ms^{-1}$
**B.** 46.4 $ms^{-1}$
**C.** 21.0 $ms^{-1}$
**D.** 25.0 $ms^{-1}$

*The following information applies to Questions 3 & 4.*

Consider a rising aircraft of mass 3 x $10^6$ kg five seconds after take off. The aircraft is powered by thrust of 4.68 x $10^5$ N.

### Question 3

Which of the following would be the best estimate for the total lift acting on the aircraft?
**A.** 3.0 x $10^6$ N
**B.** 2.5 x $10^7$ N
**C.** 3.0 x $10^7$ N
**D.** 3.4 x $10^8$ N

### Question 4

Which of the following would be the best estimate for the total drag acting on the aircraft?
**A.** 3.6 x $10^5$ N
**B.** 4.68 x $10^5$ N
**C.** 5 x $10^5$ N
**D.** 0 N

**Question 5**

Which of the following best describes the phenomenon of induced drag?

**A.** Induced drag is the combination of form and skin drag and is a function of the shape and material use in the wing.
**B.** Induced drag is produced when Bernoulli lift is generated as the lift acts parallel to the wing surface.
**C.** Induced drag is produced when Bernoulli lift is generated, as the lift acts perpendicular to the wing surface.
**D.** Induced drag is produced when Newtonian lift is generated, as the lift acts perpendicular to the wing surface.

**Question 6**

What would be the result if the angle of attack were increased too much for a given wing shape and airspeed?

**A.** Excessive turbulence would lead to a stall.
**B.** The lift-to-drag ratio would decrease
**C.** The plane would roll.
**D.** Nothing, the angle of attack simply describes the direction of travel.

**Question 7**

Which control surface is required to yaw the aircraft?

**A.** Ailerons
**B.** Rudder
**C.** Elevator
**D.** Air brake

A plane is poorly trimmed and is experiencing an unbalanced upward torque of 1200 Nm on its right wing.

**Question 8**

Which of the following would best approximate the location and direction of an 800 N force on the left wing?

**A.** 1.5 m from the centre of the aircraft, directed down.
**B.** 0.67 m from the centre of the aircraft, directed up.
**C.** 1.5 m from the centre of the aircraft, directed up.
**D.** 0.67 m from the centre of the aircraft, directed down.

**Question 9**

Which of the following statements is **incorrect** in terms of the concept of Bernoulli lift?

**A.** Airflow over the upper surface of a wing is faster than the bottom
**B.** Total air pressure near the upper surface of the wing is less on the top than the bottom
**C.** The air pressure on the underside surface of the wing is lower than the top
**D.** The air pressure on the top and bottom of the wing surface is not balanced.

**Question 10**

Which of the following statements regarding the concept of Newtonian lift is correct?

**A.** As an aerofoil moves through the air, it deflects air upwards, this provides lift to the wing
**B.** The lift force ($F_{air\ on\ wing}$) is the Newtonian pair to the surrounding air being deflected downwards ($F_{wing\ on\ air}$)
**C.** The lift force is due to unbalanced pressures on either side of the aerofoil surface
**D.** The lift force is due to faster moving air on the upper side of the wing.

**END OF DETAILED STUDY 4**
**SECTION B -** continued
**TURN OVER**

## Detailed Study 5 – Sustainable energy sources

### Question 1

Which of the following could NOT be considered as sustainable energy sources?
**A.** Solar power through a photovoltaic cell array
**B.** Hydroelectric power generation
**C.** Wind power generation
**D.** Natural gas fired power station

### Question 2

Which of the following best describes the energy transformation for a photovoltaic cell?
**A.** Light to electrical
**B.** Heat to electrical
**C.** Electrical to light
**D.** Heat to light

### Question 3

What class of energy is thermal energy usually considered, in the context of power generation?
**A.** Low grade, because it can be converted efficiently to a more useable form
**B.** High grade, because it can be converted efficiently to a more useable form
**C.** High grade, because it can be converted efficiently to a more useable form
**D.** Low grade, because is cannot be converted efficiently to a more useable form

### Question 4

Which of the following options correctly lists the energy types correctly to fit the statement below:

An electric motor takes the _____ energy from a battery that has been converted to _____ energy. The motor converts this to _____ energy, then lifts a heavy mass, resulting in a change in _____ energy.

**A.** ELECTRICAL, KINETIC, CHEMICAL, POTENTIAL
**B.** CHEMICAL, ELECTRICAL ,KINETIC, POTENTIAL
**C.** POTENTIAL, ELECTRICAL, CHEMICAL, KINETIC
**D.** ELECTRICAL, CHEMICAL, KINETIC, POTENTIAL

*The following information applies to Questions 5 & 6.*

An electric motor is powered by a 6 V battery. An ammeter connected in series with the motor indicates a current of 1.3 A as the motor lifts a 250 g mass a distance of 1.4 m vertically in 0.6 seconds.

**Question 5**

Which of the following is the best estimate for the input energy used by the motor?
**A.** 4.68 J
**B.** 7.8 J
**C.** 6 J
**D.** 1.3 J

**Question 6**

Which of the following is the best estimate for the overall efficiency of the motor?
**A.** 7.5 %
**B.** 25
**C.** 75 %
**D.** 140 %

*The following information applies to Questions 7 & 8.*

Solar insolation at a specific site is measured at 860 $Wm^{-2}$, for an average of 7 hrs per day. An array of area 8 $m^2$ has an overall efficiency of 16%.

**Question 7**

Which of the following is best estimate for the input energy available to the array over a 7 day period?
**A.** $1.7 \times 10^2$ MJ
**B.** $1.2 \times 10^3$ MJ
**C.** $1.2 \times 10^9$ MJ
**D.** 0.38 MJ

**Question 8**

Which of the following is the best estimate for the output energy of the array in kWh over a 7 day period?
**A.** $1.9 \times 10^2$ kWh
**B.** 54 kWh
**C.** 337 kWh
**D.** 283 kWh

**Question 9**

Which of the following is one advantage of using solar arrays in equatorial regions

**A.** The solar insolation rates are more variable
**B.** The solar insolation rates are more constant
**C.** Systems are more efficient when used in humid conditions
**D.** Solar arrays can be used at night.

**Question 10**

An incandescent light globe is relatively inefficient (~10%) in its energy conversion. What is the primary "waste" energy that leads to this poor efficiency?

**A.** Heat
**B.** Sound
**C.** Light
**D.** Electrical

**END OF DETAILED STUDY 5**
**SECTION B -** continued

**Detailed Study 6 – Medical physics**

**Question 1**

Which of the following types of radioisotopes would be preferred for maximum penetration and safer medical diagnosis?

**A.** Alpha
**B.** Beta
**C.** Gamma
**D.** Neutrons

*The following information applies to Questions 2 to 5.*

64 mg of the commonly used imaging radioisotope fluorine-18, a $\beta^+$ emitter with a half-life of 110 mins is delivered to a hospital

**Question 2**

What mass of F-18 will remain after 220 mins?

**A.** 32 mg
**B.** 16 mg
**C.** 6.4 mg
**D.** 60 mg

**Question 3**

How many minutes will need to elapse before 8 mg of F-18 remains?

**A.** 880 mins
**B.** 110 mins
**C.** 330 mins
**D.** 220 mins

**Question 4**

F-18 is produced in a cyclotron, where O-18 atoms are bombarded with fast protons. Which of the following would best summarise this reaction? (note: *p* = proton, *n* = neutron)

**A.** ${}^{18}_{8}O + {}^{1}_{1}p \rightarrow {}^{18}_{9}F$
**B.** ${}^{18}_{9}O + {}^{1}_{0}p \rightarrow {}^{18}_{9}F + {}^{1}_{0}n$
**C.** ${}^{18}_{8}O + {}^{1}_{1}p \rightarrow {}^{18}_{9}F + {}^{1}_{0}n$
**D.** ${}^{18}_{8}O + {}^{1}_{0}p \rightarrow {}^{18}_{8}F + {}^{1}_{0}n$

**Question 5**

Which of the following statements would best state why alpha particles are NOT often used?

**A.** The alpha particles would have more penetration power and be more dangerous
**B.** The alpha particles would have less ionization ability and therefore be less effective
**C.** The alpha particles are much lighter than $\beta^+$ and would therefore be hard to detect
**D.** The alpha particles would have more ionization ability and therefore be more dangerous

**Question 6**

Why do radioisotopes used in medical diagnosis tend to have short half-lives?

**A.** They are easier to produce
**B.** They do not remain in the body of the target patient for too long, limiting overall exposure
**C.** Shorter half lives decreases the activity rate of decay
**D.** They have less penetration power

**Question 7**

Which type of fibre optic bundle would be required for effective imaging during surgery?

**A.** Coherent
**B.** Incoherent
**C.** Either coherent or incoherent
**D.** Graded index, incoherent bundle

**Question 8**

Which of the following properties is NOT one of the advantages of lasers used in medical procedures?

**A.** Low intensity, incoherent light source
**B.** Precise, low convergent source
**C.** Good source of heat for cutting
**D.** Can be directed using a fibre optic guide.

**Question 9**

Which of the following statements explains why X-rays are better suited for imaging bone rather than soft tissue?

**A.** X-rays are readily absorbed by bone, but not soft tissue, giving clearer images of bones as shadows on film.
**B.** X-rays are readily absorbed by soft tissue, but not by bone, giving clearer images of bones as shadows on film.
**C.** Bones are deeper inside the patient, so X-rays will tend to finish at the bone site after their fixed penetration distance.
**D.** X-rays have much lower energy per photon than regular visible light.

**Question 10**

Which of the following would best suit detailed imaging of brain tissue?

**A.** MRI
**B.** X-Ray
**C.** Ultrasound
**D.** PET scan

**END OF QUESTION AND ANSWER BOOK**

# DATA SHEET

| **Radioactivity** | **Electricity** |
|---|---|
| Absorbed Dose = $\frac{Energy}{Mass}$ | Electric current = $I = \frac{q}{t}$ |
| Dose Equivalent = Absorbed Dose x Quality Factor | Resistance = $R = \frac{V}{I}$ |
| Half Life: $N = N_0 \times 0.5^{\frac{t}{t_{half}}}$ | Power transferred = $P = VI = \frac{V^2}{R} = I^2 R$ |
| **Astrophysics** | Resistors in series: $R_{total} = R_1 + R_2 + .....$ |
| Speed of light in a vacuum: $c$ = 3 x $10^8$ $ms^{-1}$ | Resistors in parallel: $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} .....$ |
| Parallax angle: $\theta = \frac{1}{d}$ | AC voltages: $V_{peak} = \sqrt{2} \times V$ RMS<br>Frequency and period: $f = \frac{1}{T}$ |
| Einstein's Equation: $E = \Delta mc^2$ | **Alternative Energy Sources** |
| 1 parsec = 3.086 x $10^{16}$ m | Efficiency (%) = $\frac{Useful\_energy\_output}{Energy\_input} \times 100$ |
| 1 AU = 1.50 x $10^{11}$ m | Pressure = $\frac{force}{area}$ |
| 1 amu = 1.7 x $10^{-27}$ kg | |
| **Aerospace** | **Nuclear Energy** |
| Power: $P = \frac{E}{t}$ or $P = Fv$ | $q$ = 1.6 x $10^{-19}$ C |
| Continuity: $Q = v_1 A_1 = v_2 A_2$ | |
| Bernoulli: $\frac{1}{2}\rho {v_1}^2 + \rho g h_1 + P_1 = \frac{1}{2}\rho {v_2}^2 + \rho g h_2 + P_2$ | |
| Torque: $\tau = Fd$ | |

## Prefixes

| | | |
|---|---|---|
| n = nano = $10^{-9}$ | m = milli = $10^{-3}$ | M = mega = $10^6$ |
| μ = micro = $10^{-6}$ | k = kilo = $10^3$ | G = giga = $10^9$ |

## SECTION B – DETAILED STUDY ANSWER SHEET

**Detailed Study Attempted – Please tick appropriate box**

| | |
|---|---|
| **1. Astronomy** | |
| **2. Astrophysics** | |
| **3. Energy from the Nucleus** | |
| **4. Flight** | |
| **5. Sustainable Energy Sources** | |
| **6. Medical Physics** | |

**Answers – Circle ONE of A-D for each of the ten multiple choice questions.**

| Question | Answer | | | |
|---|---|---|---|---|
| **1** | **A** | **B** | **C** | **D** |
| **2** | **A** | **B** | **C** | **D** |
| **3** | **A** | **B** | **C** | **D** |
| **4** | **A** | **B** | **C** | **D** |
| **5** | **A** | **B** | **C** | **D** |
| **6** | **A** | **B** | **C** | **D** |
| **7** | **A** | **B** | **C** | **D** |
| **8** | **A** | **B** | **C** | **D** |
| **9** | **A** | **B** | **C** | **D** |
| **10** | **A** | **B** | **C** | **D** |