Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Time 1 hour 30 minutes

Paper reference **8PH0/02**

Physics

Advanced Subsidiary
PAPER 2: Core Physics II

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions in Sections A and B.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations including units where appropriate.
- Good luck with your examination.

Turn over

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P 6 7 0 8 6 A 0 1 2 4

Pearson

SECTION A

Answer ALL questions.

All multiple choice questions must be answered with a cross in the box ☒ for the correct answer from A to D.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following best describes the newton as used in physical measurements?

☐ **A** base quantity

☐ **B** base unit

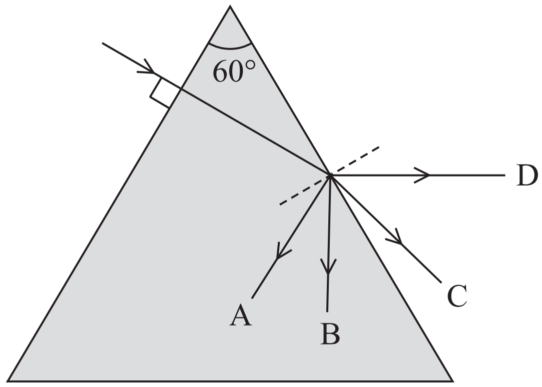
☐ **C** derived quantity

☐ **D** derived unit

(Total for Question 1 = 1 mark)

Questions 2 and 3 refer to the following information.

A ray of light, in air, is incident on the edge of a triangular glass prism as shown.
The critical angle for a light ray meeting a glass to air boundary is 35°.



2 Which path, A, B, C or D, will the ray follow?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 1 mark)

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3 Which of the following gives the value of the refractive index of the glass?

☒ **A** $\sin 35$

☒ **B** $\dfrac{1}{\sin 35}$

☒ **C** $\sin^{-1}\left(\dfrac{1}{35}\right)$

☒ **D** $\dfrac{1}{\sin^{-1}\left(\dfrac{1}{35}\right)}$

(Total for Question 3 = 1 mark)

Questions 4 and 5 refer to the following information.

The speed v of a transverse wave on a string is given by

$$v = \sqrt{\frac{T}{\mu}}$$

where μ is the mass per unit length of the string and T is the tension in the string.

4 μ can be calculated from measurements of the mass and length of the string.

The percentage uncertainty in the measurement of mass is 0.4%.
The percentage uncertainty in the measurement of length is 0.05%.

Which of the following is the percentage uncertainty in the calculated value for μ?

☒ **A** 0.4 + 0.05

☒ **B** 0.4 − 0.05

☒ **C** 0.4 × 0.05

☒ **D** 0.4 ÷ 0.05

(Total for Question 4 = 1 mark)

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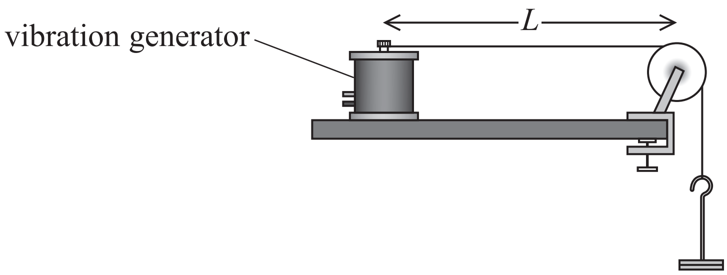
5 A fixed length L of string is connected to a vibration generator and held under tension T as shown. The frequency of the vibration generator is varied until, at a frequency f, a standing wave with one antinode is observed. T is increased and the procedure is repeated.



Which of the following describes the variation in f as T increases?

☒ **A** decreases linearly

☒ **B** decreases non-linearly

☒ **C** increases linearly

☒ **D** increases non-linearly

(Total for Question 5 = 1 mark)

P 6 7 0 8 6 A 0 4 2 4

6 The following measurements were made to determine the Young modulus of a metal bar.

original length of bar = 0.50 m
area of cross section = $4.5 \times 10^{-4}\,\text{m}^2$
tensile force applied to bar = 36 000 N
extension of bar = $2.0 \times 10^{-4}\,\text{m}$

Which of the following gives the Young modulus of the metal?

☒ **A** $\dfrac{36000 \times 0.50}{4.5 \times 10^{-4} \times 2.0 \times 10^{-4}}$

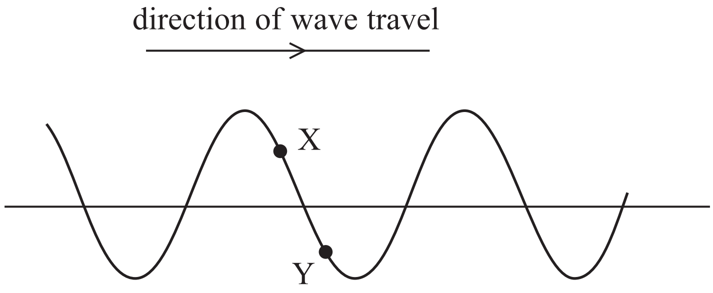
☒ **B** $\dfrac{4.5 \times 10^{-4} \times 2.0 \times 10^{-4}}{36000 \times 0.50}$

☒ **C** $\dfrac{36000 \times 2.0 \times 10^{-4}}{4.5 \times 10^{-4} \times 0.50}$

☒ **D** $\dfrac{4.5 \times 10^{-4} \times 0.50}{36000 \times 2.0 \times 10^{-4}}$

(Total for Question 6 = 1 mark)

7 The diagram shows the position of two particles, X and Y, on a transverse wave. The wave is travelling from left to right.



Which of the following describes the directions in which the particles at X and Y are moving at the instant shown?

		Particle X	Particle Y
☒	**A**	down	down
☒	**B**	down	up
☒	**C**	up	down
☒	**D**	up	up

(Total for Question 7 = 1 mark)

8 A beam of light from a torch with power *P* is shone onto a surface. The light is spread over a circular area with a radius *r*.

Which of the following gives the intensity of the light on the surface?

☒ **A** $P \times 4\pi r^2$

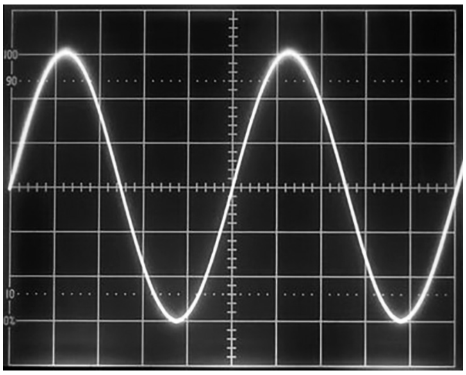
☒ **B** $\dfrac{P}{4\pi r^2}$

☒ **C** $P \times \pi r^2$

☒ **D** $\dfrac{P}{\pi r^2}$

(Total for Question 8 = 1 mark)

9 In an investigation to determine the speed of sound in air, a student sets up an oscilloscope to display the waveform of a sound wave as shown.



The timebase is set to 25 µs / division.

(a) Determine the frequency of the sound wave.

(2)

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Frequency = ...

(b) The student sets the timebase on the oscilloscope to a lower value per division.

Describe any changes to the appearance of the waveform on the screen.

(1)

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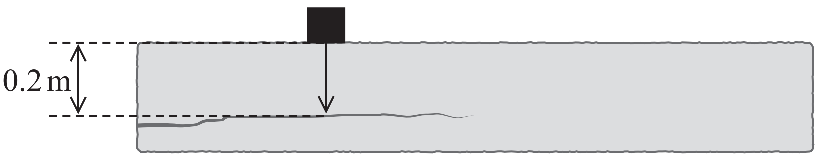
(Total for Question 9 = 3 marks)

10 Concrete is a material used in buildings due to its high compressive strength.

(a) A concrete post can be checked for internal cracks using a pulse-echo technique. A transducer that transmits and receives ultrasound pulses is positioned against the side of the post as shown.



A pulse hits a crack and is reflected and is then detected by the transducer.

Deduce whether a crack at a depth of 0.2 m can be detected.

time between pulses = 160 μs
speed of sound in concrete = 3200 m s^{-1}

(3)

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(b) Another concrete post is reinforced with steel rods, to increase its tensile strength. A steel rod is under a tensile load of 130 N and extends by 4.0×10^{-4} m. The steel has not reached its elastic limit.

Calculate the elastic strain energy in the steel rod.

(2)

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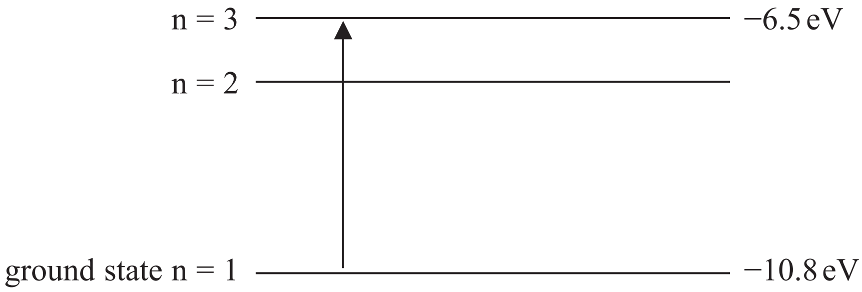
Elastic strain energy = ...

(Total for Question 10 = 5 marks)

11 An electron in its ground state absorbs electromagnetic radiation of wavelength λ.
The energy level diagram represents the resulting energy transition of the electron.



(a) Calculate the wavelength of radiation absorbed by the electron.

(3)

Wavelength = ...

(b) The electron eventually returns to its ground state.

Explain, with reference to the energy level diagram, how this may result in the emission of radiation with a longer wavelength than λ.

(3)

(Total for Question 11 = 6 marks)

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12 Vibrations of a car engine cause a sound wave in air.

(a) Describe how the displacement of air molecules causes pressure variations in the air.

(3)

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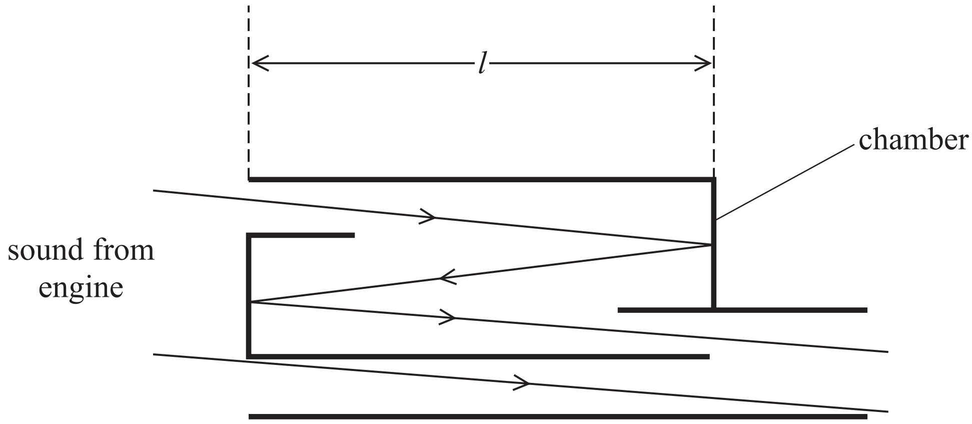
(b) A silencer is a device fitted to a car to reduce the sound from the engine. Some sound passes through the silencer chamber and is reflected twice. Some sound passes straight through the chamber without being reflected.

The simplified diagram shows the paths of the sound as it travels through the chamber. Sound leaving the chamber is a combination of sound waves from the two paths. The sound waves are in phase as they enter the chamber.



An engine produces sound with a frequency of about 140 Hz.

Explain why, to reduce this sound, the length *l* of the chamber should be about 60 cm.

speed of sound in air = $340\,\mathrm{m\,s^{-1}}$

(4)

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(Total for Question 12 = 7 marks)

***13** A student views a laptop screen through a polarising filter. Initially the screen appears normal brightness. He rotates the filter to 90° and observes that the screen appears dark.

Explain what the student observes as he gradually rotates the filter to 180° and then to 270°.

(6)

(Total for Question 13 = 6 marks)

P 6 7 0 8 6 A 0 1 2 2 4

14 A seiche is a standing wave that can form on the surface of a lake in strong winds, causing flooding and erosion.

(a) Early in 2020, a single-node seiche was observed on Lake Erie in the USA. A node formed at the centre of the lake. Antinodes formed at the two ends of the lake.

The speed v of a seiche wave is given by

$$v = \sqrt{gh}$$

where h is the mean depth of the water.

Calculate the period of oscillation of the seiche.

length of Lake Erie = 400 km
mean depth of Lake Erie = 19 m

(3)

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Period of oscillation = ...

(b) Erosion causes clay particles to be washed into the lake, making the lake cloudy. The lake can remain cloudy to a depth of about 4 m for more than 6 months.

One spherical clay particle has a radius of 2.5×10^{-7} m.

Deduce whether this particle takes more than 6 months to fall 4 m. You should assume that the water in the lake remains still.

viscosity of water = $1.0 \times 10^{-3}\ \text{kg m}^{-1}\ \text{s}^{-1}$
density of water = $1000\ \text{kg m}^{-3}$
density of clay = $2650\ \text{kg m}^{-3}$

(6)

(c) The temperature of the lake decreases with depth.

Explain how this may affect the rate at which a particle falls.

(2)

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(d) In an investigation to determine the viscosity of water, a student drops a small sphere into a cylinder of water. The student uses a stopwatch to record the time it takes for the sphere to fall through the water.

Assess whether the stopwatch is suitable for measuring the time in this investigation.

(2)

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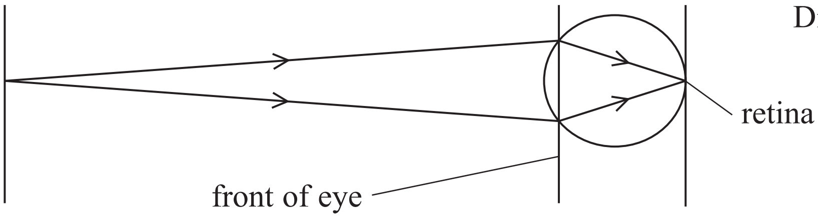
(Total for Question 14 = 13 marks)

15 The human eye acts as a converging lens system that produces an image on the retina at the back of the eye as shown.

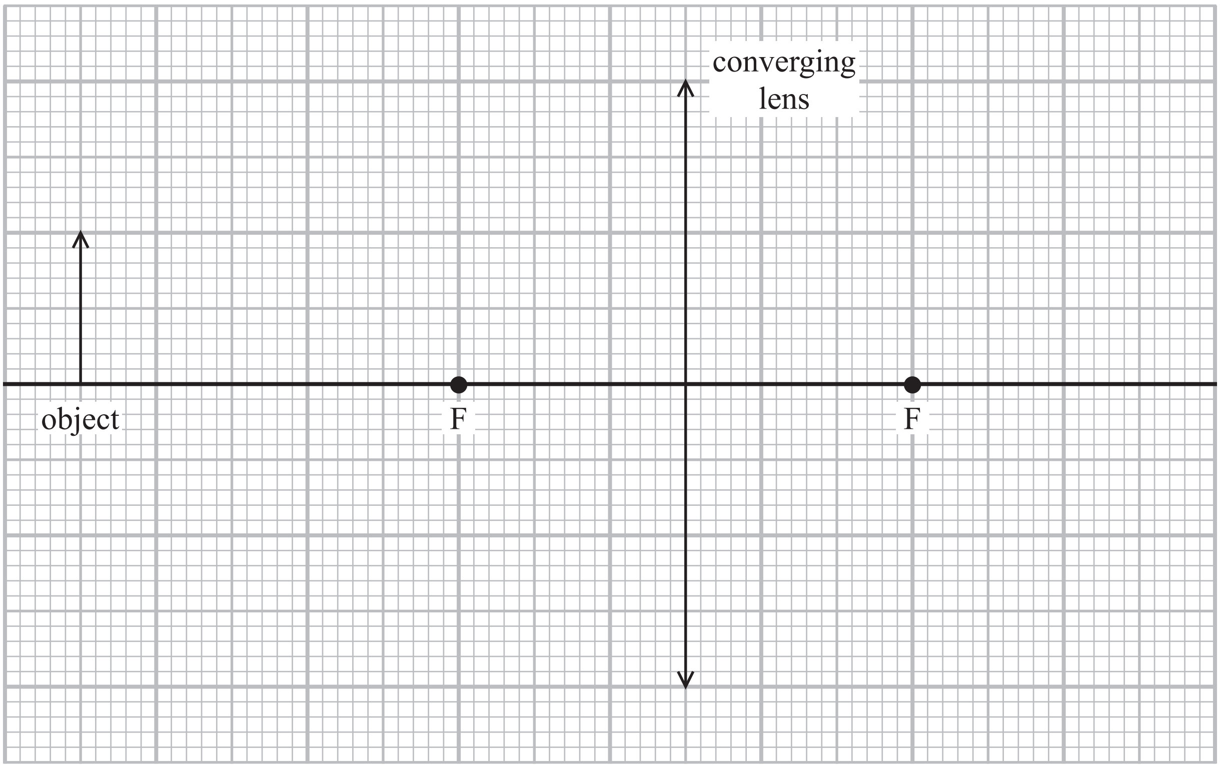
Diagram **NOT** to scale



A person with eyesight problems may wear either diverging or converging contact lenses.

(a) The diagram below shows an object in front of a converging lens.

F is the principal focus.



Determine the position and magnification of the image produced by the lens, by completing a ray diagram.

(4)

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Magnification = ...

(b) A short-sighted eye cannot focus on distant objects, because the power of the eye is too great.

One student with short sight cannot focus on objects further than 1.5 m without wearing her contact lenses.

To view distant objects, it is determined that the combined power of her eye and her contact lens should be 41.7 D.

Determine the power and type of lens needed to correct her vision. Assume the equations for thin lens apply to both lenses.

distance from eye lens to retina = 2.4 cm

(4)

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Power = ...

Type of lens ....

(Total for Question 15 = 8 marks)

TOTAL FOR SECTION A = 56 MARKS

SECTION B

Answer ALL questions in the spaces provided.

16 Read the extract and answer the questions that follow.

In the 17th century there were two proposed theories to explain the refraction of light. Using a wave model, Huygens stated that light slows down when it passes from air to water. Using a particle model, Newton stated that light speeds up when it passes from air to water. Newton's theory was more readily accepted until the speed of light in water was measured in the 19th century.

In the early 20th century, Einstein used observations from the photoelectric effect to provide evidence for the particle model of light.

Nowadays, both the wave model of light and the particle model of light are accepted, as each can be used to explain different aspects of the behaviour of light.

(a) Give two reasons why Huygens' theory for the refraction of light eventually became accepted.

(2)

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(b) A ray of light travelling in air is incident on some water with an angle of incidence of 35°. The angle of refraction is 26°.

Deduce whether this is consistent with Huygens' statement about the speed of light as it passes from air to water. Your answer should include a calculation.

(3)

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(c) Diffraction and interference can be explained using the wave model of light.

In an investigation to determine the wavelength of light from a laser, the light passed through a diffraction grating with 300 lines per millimetre.
A diffraction pattern consisting of a series of bright dots was observed on a screen.

The following data were recorded:

distance between grating and screen = 2.00 m
distance from central maximum to 2nd order maximum = 89.0 cm.

Calculate the wavelength of light from the laser.

(3)

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Wavelength = ...

(d) In a demonstration of the photoelectric effect, electromagnetic radiation is shone onto a clean metal surface. It can be shown that the metal loses negative charge when the radiation has a frequency above a certain threshold frequency.

Explain how the particle model of light is consistent with this observation.

(3)

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(e) In the 1920s, experiments demonstrating diffraction of electrons confirmed de Broglie's work on the wave nature of particles.

In one such experiment an electron had a momentum of $4.8 \times 10^{-24}\,\mathrm{kg\,m\,s^{-1}}$. Measurements confirmed that the de Broglie wavelength of the electron was $1.40 \times 10^{-10}\,\mathrm{m}$.

Deduce that these observations are consistent with the value of h given on the data sheet at the back of this exam paper.

(3)

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(Total for Question 16 = 14 marks)

17 Some sports place high stresses on the bones in the body, which can result in injury.

(a) A gymnast of mass 45 kg dismounts from a beam. Her centre of mass is displaced through 1.6 m vertically before her feet touch the ground.
As she lands, the bones in the lower part of her legs experience a force from the ground. The time between hitting the ground and coming to rest is 0.90 s.

(i) Calculate the mean force from the ground on the gymnast.

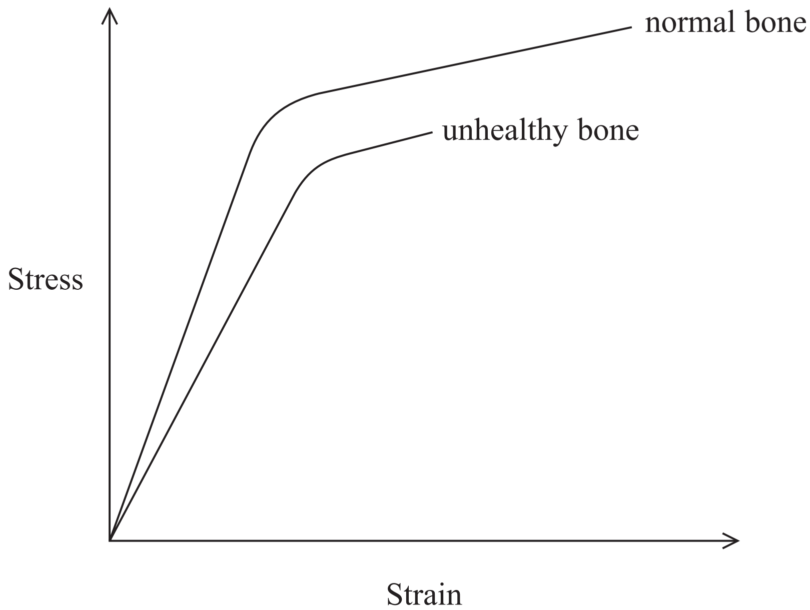
(4)

Mean force from the ground = ...

(ii) Explain how bending both knees when landing helps the gymnast prevent an injury.

(3)

(b) The graph shows how stress varies with strain for normal bone and for unhealthy bone.



Describe how the graph shows that unhealthy bone under stress is more likely to break than normal bone.

(3)

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(Total for Question 17 = 10 marks)

TOTAL FOR SECTION B = 24 MARKS
TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	

Mechanics

Kinematic equations of motion

$$s = \frac{(u+v)t}{2}$$

$$v = u + at$$

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

$$moment\ of\ force = Fx$$

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

$$E_k = \tfrac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Electricity

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$F = 6\pi\eta rv$

Hooke's law

$\Delta F = k\Delta x$

Young modulus

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$\Delta E_{el} = \frac{1}{2}F\Delta x$

Waves and Particle Nature of Light

Wave speed

$v = f\lambda$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$P = P_1 + P_2 + P_3 + \ldots$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$n\lambda = d \sin \theta$

Refractive index

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$E = hf$

Einstein's photoelectric equation

$hf = \phi + \frac{1}{2}mv^2_{max}$

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

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