Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 3 3 / 0 1	Signature	

Paper Reference(s)

6733/01

Edexcel GCE

Physics

Advanced Subsidiary

Unit Test PHY3: Topics

Thursday 21 May 2009 – Afternoon

Time: 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1A	
2B	
3C	
4D	
Total	

Materials required for examination	Items included with question papers
Nil	Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Answer ONE question only.
Indicate which Topic you are answering by putting a cross in the box (☒) at the start of the Topic.
If you change your mind, put a line through the box (☒) and then indicate your new question with a cross (☒).
In calculations you should show all the steps in your working, giving your answer at each stage.
Calculators may be used.
Include diagrams in your answers where these are helpful.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets.
The total mark for this paper is 32.
The list of data, formulae and relationships is printed at the end of this booklet.

Advice to Candidates

You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, taking account of your use of grammar, punctuation and spelling.

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If you answer this Topic put a cross in this box ☒

Topic A – Astrophysics

1. (a) Complete the table to show the mass ranges for different types of star.

Type of star	**Mass (solar masses)**
White dwarf	Less than ....
....	0.4 to 8
....	Core remnant = 1.4 to 2.5
Black hole	Core remnant > ....

(4)

(b) (i) Charge coupled devices (CCDs) can have an efficiency as great as 70%, whereas photographic emulsions may have an efficiency of less than 5%. State **two** advantages of this greater efficiency.

Advantage 1 ....

....

Advantage 2 ....

....

Give **one** advantage that photographic emulsions have over CCDs.

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(3)

(ii) A CCD has a better linearity of response than a photographic emulsion. Explain what this means in terms of imaging stars. You may be awarded a mark for the clarity of your answer.

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(3)

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(c) (i) In a star, the process of hydrogen burning involves protons fusing to form helium. Show that the energy released when four protons fuse to form one helium nucleus is approximately 4×10^{-12} J.

Masses: $^{1}_{1}p = 1.6726 \times 10^{-27}$ kg

$^{4}_{2}He = 6.6447 \times 10^{-27}$ kg

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(3)

(ii) The number of protons undergoing fusion in the Sun every second is 3.8×10^{38}.

Calculate the total energy produced by the Sun every second.

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(2)

(iii) The intensity of the Sun's radiation reaching the Earth is 1370 W m^{-2}.

Calculate the distance of the Sun from the Earth.

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(3)

(iv) The Sun has a surface temperature of 5800 °C.

Calculate the wavelength of the peak intensity radiation that it emits.

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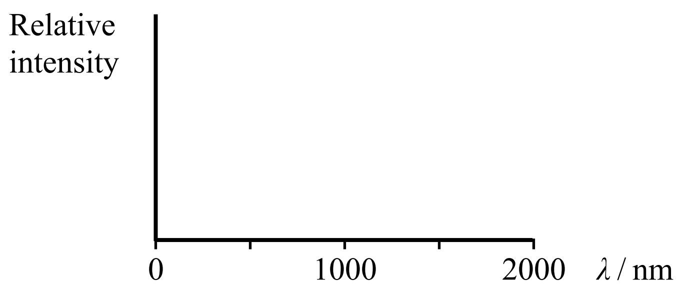
(2)

(v) Sketch a graph to show how the relative intensity of the radiation emitted by the Sun varies with wavelength.



(2)

(d) Explain what is meant by the term **main sequence star**.

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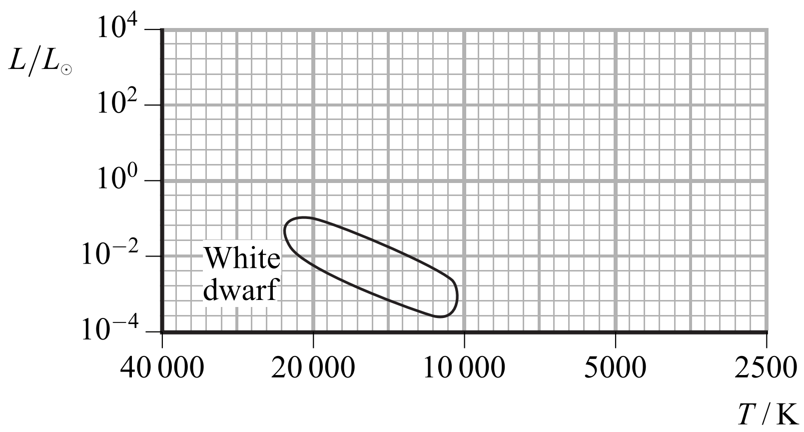
(2)

(e) A Hertzsprung-Russell diagram plots the ratio of the luminosity of a star to the luminosity of the Sun ($L_\odot = 3.9 \times 10^{26}$ W) against the star's surface temperature.

(i) Mark clearly with a cross the location of the Sun.



(1)

(ii) Add to the diagram to indicate where main sequence stars are plotted.

(2)

(iii) Add to the diagram to show the region where red giant stars are plotted. Label this region.

(1)

(iv) Estimate the radius of a white dwarf star, showing your working.

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(4)

(Total 32 marks)

Leave blank

Q1

Leave blank

If you answer this Topic put a cross in this box ☒

Topic B – Solid Materials

2. (a) Complete the table to show examples of different types of polymer.

Type of polymer	Material
Amorphous thermoplastic	....
Semi-crystalline thermoplastic	....
....	Melamine

(3)

(b) Glass objects are often referred to as being fragile. Circle any of the following words which could also be used to describe the properties of glass at room temperature.

brittle flexible plastic stiff tough

(2)

(c) A cylindrical glass rod has a radius of 2.0 mm, a length of 60 cm and a Young modulus of 7.0×10^{10} Pa. A tension of 460 N is applied to stretch the rod along its length.

(i) Show that its extension is approximately 0.3 mm.

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(4)

(ii) Hence calculate the energy density of the glass rod when it is loaded.

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(4)

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(iii) A piece of mild steel, of identical size to the glass rod, is also subjected to the same force. The Young modulus of mild steel is 20×10^{10} Pa.

Explain how the extension of the steel rod compares with that of the glass rod.

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(2)

(d) Describe the process by which a pre-stressed reinforced concrete beam is produced. Illustrate your answer with labelled diagrams. You may be awarded a mark for the clarity of your answer.

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State which parts of the beam are in tension and which are in compression.

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(5)

Leave blank

(e) (i) Explain what is meant by a composite material.

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(2)

(ii) Chipboard, carbon-fibre and plywood are all examples of composite materials.

State which of these materials is a laminate and which is a particle composite.

Laminate ....

Particle composite ....

With the aid of **two** labelled diagrams explain the difference between a laminate and a particle composite.

Laminate	Particle Composite
....	....
....	....
....	....
....	....

(4)

N 3 1 1 3 5 A 0 8 2 0

(f) (i) Describe the processes of work hardening and quench hardening.

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(2)

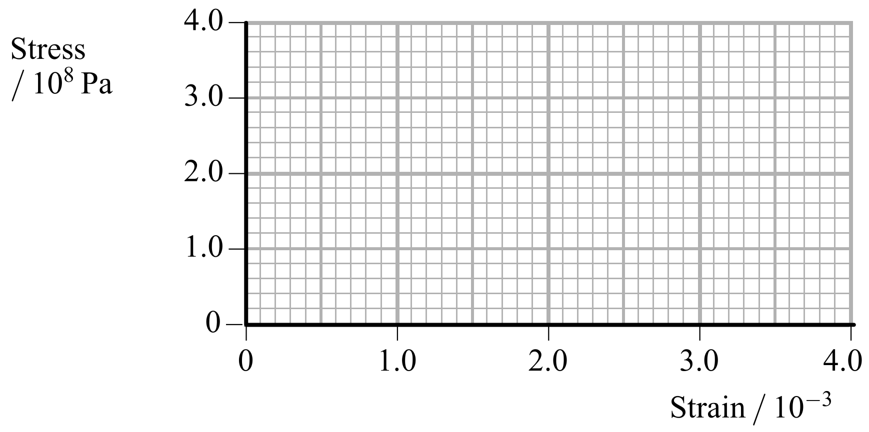
(ii) Circle two properties of a metal that are changed when it is work hardened.

brittleness flexibility hardness toughness

(1)

(g) Mild steel has a Young modulus of 2.0×10^{11} Pa and a yield stress of 2.5×10^{8} Pa.

Sketch a stress-strain graph for mild steel up to a strain of 3.0×10^{-3}. Show your working.



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(3)

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Q2

(Total 32 marks)

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If you answer this Topic put a cross in this box ☒

Topic C – Nuclear and Particle Physics

3. (a) (i) Complete the table to show examples of different particles and their classifications.

Particle	**Classification**
Pion	Meson
....	Lepton
....	Baryon
Muon neutrino	....
Gluon	....

(4)

(ii) Electrons, up quarks, down quarks and all neutrinos are fundamental particles.

State the difference between a fundamental particle and a composite particle.

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(1)

(iii) List the **six** fundamental particles not mentioned in part (ii). Do not include antiparticles or exchange particles.

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(2)

(iv) Antimatter versions of these particles have been detected.

State **one** similarity and **one** difference between an electron and a positron.

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State what happens when they interact with each other.

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(3)

Leave blank

(b) The equation shows the decay of a sigma-plus particle Σ^+ to a particle X^+ and a π^0 particle. The equation also shows the quark flavours for the Σ^+ and π^0 particles. The X^+ particle consists of three quarks.

$$\underset{(uus)}{\Sigma^+} \longrightarrow \underset{(qqq)}{X^+} + \underset{(u\bar{u})}{\pi^0}$$

(i) Show that this decay is permitted by using appropriate conservation laws.

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(2)

(ii) Use information from this decay to calculate the charge on a strange quark. Justify your answer.

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(1)

(iii) List the four fundamental interactions. State what each interaction can act upon, and whether it could be responsible for this Σ^+ decay.

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(4)

(iv) In this Σ^+ decay, the strange quark turns into a down quark.

State which exchange particle might be involved in this decay.

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(1)

(v) Identify particle X.

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(1)

Leave blank

(c) The density of a nucleus of indium is 2.29×10^{17} kg m^{-3}.

(i) Calculate the mass of an indium nucleus of radius 5.84×10^{-15} m.

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(3)

(ii) Hence show that the nucleon number of this isotope is 115.

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(1)

(d) (i) Complete the equation for β^- decay and add proton and nucleon numbers.

$$n \longrightarrow \ldots.. \quad + \quad \beta^- \quad + \quad \bar{\nu}$$

(2)

(ii) Sketch the energy spectrum of β^- particles from a single source. Add a suitable label to each axis.

(3)

Leave blank

(iii) Explain how the shape of this graph led to the prediction of the existence of an antineutrino. You may be awarded a mark for the clarity of your answer.

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(4)

Q3

(Total 32 marks)

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If you answer this Topic put a cross in this box ☒

Topic D – Medical Physics

4. (a) Complete the table to show uses of different sources.

Source	**Use in medical physics**
keV X-rays	....
....	Soft tissue imaging
....	Radiotherapy
Cobalt-60 source	....

(4)

(b) (i) Molybdenum $^{99}_{42}Mo$ decays to ^{99m}Tc by beta-minus emission.

Write a balanced nuclear equation for this decay.

....
(1)

(ii) State and explain the meaning of the letter m in ^{99m}Tc.

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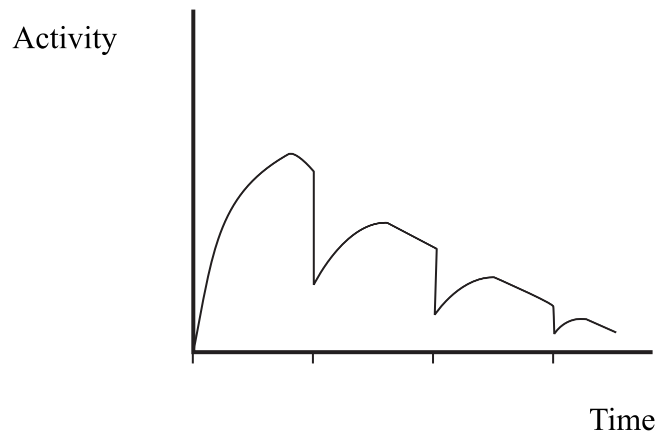
(2)

(iii) ^{99m}Tc is produced in hospitals from molybdenum in an elution cell. The graph shows how the activity of the elution cell varies with time.



Add a suitable time scale and unit to the graph.

(1)

N 3 1 1 3 5 A 0 1 4 2 0

Leave blank

(iv) Explain why the graph has several vertical lines at regular intervals.

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(2)

(v) Describe the process of elution that is used to collect the ^{99m}Tc. You may be awarded a mark for the clarity of your answer.

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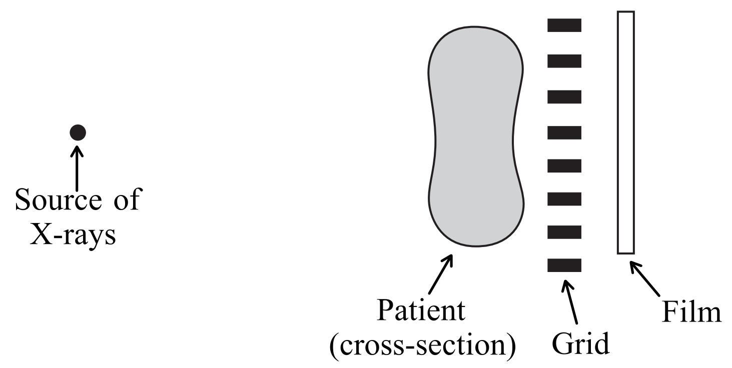
(4)

(c) The diagram shows the position of an anti-scatter grid being used in X-ray imaging.



(i) State the name of the material the grid is made from.

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(1)

(ii) Add X-ray paths to the diagram to show how an anti-scatter grid works.
(3)

N 3 1 1 3 5 A 0 1 5 2 0

Turn over

Leave blank

(d) In ultrasonic diagnosis the reflection coefficient α can be written as

$$\alpha = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2$$

(i) State what is represented by Z_1 and Z_2 in this equation.

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(2)

(ii) Show that the units of Z are kg m^{-2} s^{-1}.

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(2)

(iii) Use the following data to calculate the reflection coefficient for a muscle-fat boundary.

Medium	***Z* / kg m^{-2} s^{-1}**
Fat	1.38×10^6
Muscle	1.70×10^6

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(2)

(iv) Hence express as a percentage the ratio of ultrasound that will be transmitted through a muscle-fat boundary.

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(2)

(v) Suggest a value of specific acoustic impedance for the coupling medium used for this scan.

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(1)

Leave blank

(e) (i) State the maximum X-ray energy that could be produced by an X-ray tube which has an accelerating voltage of 65 000 V.

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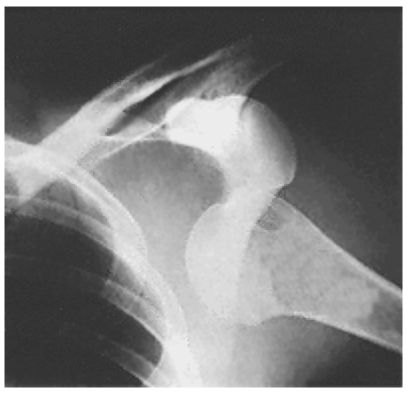
(1)

(ii) The X-ray image shows a dislocated shoulder.



Explain why some areas of the image are white, whilst others are grey. Use the information given to quantify your explanation.

Medium	**Atomic number**
Bone	20
Soft tissue	9

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(4)

Q4

(Total 32 marks)

TOTAL FOR PAPER: 32 MARKS

END

N 3 1 1 3 5 A 0 1 7 2 0

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Acceleration of free fall	$g = 9.81 \text{m s}^{-2}$	(close to the Earth)
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19} \text{ C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$	
Molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

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

$$v^2 = u^2 + 2ax$$

Forces and moments

Moment of F about O = $F \times$ (Perpendicular distance from F to O)

Sum of clockwise moments about any point in a plane = Sum of anticlockwise moments about that point

Dynamics

Force $\quad F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $\quad F\Delta t = \Delta p$

Mechanical energy

Power $\quad P = Fv$

Radioactive decay and the nuclear atom

Activity $\quad A = \lambda N \quad$ (Decay constant λ)

Half-life $\quad \lambda t_{\frac{1}{2}} = 0.69$

Electrical current and potential difference

Electric current	$I = nAQv$	
Electric power	$P = I^2 R$	

Electrical circuits

Terminal potential difference	$V = \mathcal{E} - Ir$	(E.m.f. $\mathcal{E}$; Internal resistance r)
Circuit e.m.f.	$\Sigma\mathcal{E} = \Sigma IR$	
Resistors in series	$R = R_1 + R_2 + R_3$	
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	

Heating matter

Change of state	energy transfer $= l\Delta m$	(Specific latent heat or specific enthalpy change l)
Heating and cooling	energy transfer $= mc\Delta T$	(Specific heat capacity c; Temperature change ΔT)
Celsius temperature	$\theta/°\mathrm{C} = T/\mathrm{K} - 273$	

Kinetic theory of matter

Temperature and energy	$T \propto$ Average kinetic energy of molecules	
Kinetic theory	$p = \frac{1}{3}\rho\langle c^2\rangle$	

Conservation of energy

Change of internal energy	$\Delta U = \Delta Q + \Delta W$	(Energy transferred thermally ΔQ; Work done on body ΔW)
Efficiency of energy transfer	$= \frac{\text{Useful output}}{\text{Input}}$	
Heat engine	maximum efficiency $= \frac{T_1 - T_2}{T_1}$	

Astrophysics

Stefan-Boltzmann law	$L = \sigma T^4 \times$ surface area	(Luminosity L; Stefan constant σ)
Wien's law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K	
Estimating distance	intensity $= L/4\pi D^2$	
Mass-energy	$\Delta E = c^2 \Delta m$	(Speed of light in vacuum c)

Solid materials

Hooke's law	$F = k\Delta x$	
Stress	$\sigma = \frac{F}{A}$	
Strain	$\varepsilon = \frac{\Delta l}{l}$	
Young modulus	$E = \frac{\text{Stress}}{\text{Strain}}$	
Work done in stretching	$\Delta W = \frac{1}{2} F\Delta x$	(provided Hooke's law holds)
Energy density	= Energy/Volume	

Nuclear and particle physics

Nuclear radius	$r = r_0 A^{1/3}$	(Nucleon number A)
Mass-energy	$1\ \text{u} = 930\ \text{MeV}$	
Quark charge/e	up $= +\frac{2}{3}$; down $= -\frac{1}{3}$	

Medical physics

Effective half-life	$\frac{1}{t_e} = \frac{1}{t_r} + \frac{1}{t_b}$	(Radioactive half-life t_r; Biological half-life t_b)
Inverse square law	$I = P/4\pi r^2$	(Intensity I; Power P of a point source; Distance r from point source)
Acoustic impedance	$Z = c\rho$	(Speed of sound in medium c; Density of medium ρ)
Reflection coefficient	$= (Z_1 - Z_2)^2/(Z_1 + Z_2)^2$	

Experimental physics

$$\text{Percentage uncertainty} = \frac{\text{Estimated uncertainty} \times 100\%}{\text{Average value}}$$

Mathematics

$$\sin(90° - \theta) = \cos\theta$$

Equation of a straight line	$y = mx + c$	
Surface area	cylinder $= 2\pi rh + 2\pi r^2$	
	sphere $= 4\pi r^2$	
Volume	cylinder $= \pi r^2 h$	
	sphere $= \frac{4}{3}\pi r^3$	
For small angles:	$\sin\theta \approx \tan\theta \approx \theta$	(in radians)
	$\cos\theta \approx 1$	