SI Units

1. The table below shows four physical quantities and their units.

Which row is correct?

	Physical quantity	Unit
A	strain	pascal
B	charge	coulomb
C	power	joule
D	force constant	newton

Your Answer ☐

[1]

2. Which electrical quantity has S.I. units ampere-second (A s)?

A charge
B current
C resistance
D potential difference

Your Answer ☐

[1]

3. Two resistors of resistances 120 Ω and 500 Ω are connected in **parallel**.
The percentage uncertainty in the value of resistance of each resistor is 10%.

What is the correct value of the total resistance and the percentage uncertainty?

A 97 Ω ± 10%
B 97 Ω ± 20%
C 620 Ω ± 10%
D 620 Ω ± 20%

Your Answer ☐

[1]

4. Which of the following units is **not** an S.I. base unit?

A ampere
B mole
C volt
D kilogram

Your Answer

[1]

5. In astronomy, distance can be measured in different units.

Which one of the following distances is the **largest**?

A 4.22×10^{16} m
B 1.91 pc
C 3.42 ly
D 593AU

Your Answer

[1]

6. The latent heat of vaporisation of a liquid is 2300 kJ kg^{-1} and it has a molar mass of 0.018 kg mol^{-1}.

What is the energy required to change 30 moles of the liquid to gas?

A 4.1×10^4 J
B 1.2×10^6 J
C 6.9×10^7 J
D 3.8×10^9 J

Your Answer

[1]

7. Which one of the following prefixes represents the smallest multiplication factor?

A femto (f)
B micro (μ)
C nano (n)
D pico (p)

Your Answer

[1]

8. The freezing point of ethanol is 159 K.
What is 159 K in °C?

A – 432 °C
B – 114 °C
C 114 °C
D 432 °C

Your Answer

[1]

9. Which pair of quantities have the same S.I. base units?

A strain, elastic potential energy
B strain, force constant
C stress, force constant
D stress, Young modulus

Your Answer

[1]

10. Which quantity has the unit hertz (Hz)?

A frequency
B acceleration
C phase difference
D angular frequency

Your Answer

[1]

11. Which is **not** a unit of energy?

A kW h
B eV
C J
D W

Your Answer

[1]

12. A student is doing an experiment on the magnetic force experienced by a current-carrying wire in a uniform magnetic field. The magnetic flux density *B* can be varied.

For a particular flux density, the current in the wire is 2.0A. The length of the wire in the field is 0.12 m. The angle between the current and the magnetic field is 30°. The force experienced by the wire is 7.7×10^{-2} N.

The student calculates *B* and records the results in a table.

Which row shows the correct table heading for *B* and the correct value for *B*?

	Table heading for *B*	**Value for *B***
A	*B* / T	0.37
B	*B* / T	0.64
C	*B* / Wb	0.37
D	*B* / Wb	0.64

Your Answer

[1]

13. The total energy released in a single fusion reaction is 4.0 MeV.

What is the change in mass in this fusion reaction?

A 7.1×10^{-36} kg
B 7.1×10^{-30} kg
C 2.1×10^{-21} kg
D 4.4×10^{-17} kg

Your Answer

[1]

14. A long metal wire is stretched between two fixed points across a laboratory bench.
The speed v of the transverse wave on the stretched wire is given by the equation

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

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

The SI base units of v, T and μ are shown below.

$v \rightarrow$ m s^{-1} $T \rightarrow$ kg m s–2 $\mu \rightarrow$ kg m^{-1}

Show that the equation above is homogeneous.

[1]

15 (a).

State **one** S.I. base quantity other than length, mass and time.

____ **[1]**

(b). Fig. 17 shows two resistors **X** and **Y** connected in series.

Fig. 17

The resistors are wires. Both wires have the same length L and diameter d. The material of **X** has resistivity ρ and the material of **Y** has resistivity 2ρ.

i. Show that the total resistance R of the wires is given by the equation

$$R = \frac{12\rho L}{\pi d^2}.$$

[2]

ii. A student uses the equation in **(i)** to determine *R*.
The table below shows the data recorded by the student in her lab book.

Quantity	**Value**
ρ	4.7×10^{-7} Ωm
L	9.5 ± 0.1 cm
d	0.270 ± 0.003 mm

1. Name the likely instruments used by the student to measure *L* and *d*.

L:

----

d:

-- **[1]**

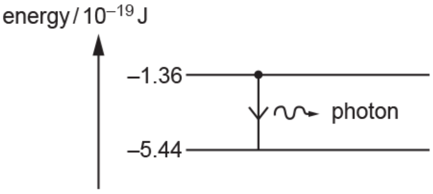
2. Use the data in the table and the equation in **(i)** to determine *R* and the absolute uncertainty. Write your answer to the correct number of significant figures.

R = ... ± .... Ω **[4]**

3. The instrument used to measure *d* has a zero-error. The measured *d* is much **larger** than the actual value.
Discuss how the actual value of *R* compares with the value calculated above.

-- **[1]**

16. The diagram below shows two energy levels for the electron in the hydrogen atom.



The electron makes the transition shown by the arrow.

What is the wavelength of the photon emitted?

A 293 nm
B 366 nm
C 488 nm
D 1460 nm

Your Answer ☐

[1]

17. The kilogram, metre and second are SI base units.

Determine the unit for *power* in terms of these SI units.

unit for power = ... **[1]**

18. Which physical quantity has the same base units as energy?

A. moment
B. momentum
C. force
D. pressure

Your Answer ☐

[1]

19. The current in a lamp is 2.0 mA. The potential difference across the lamp is 6.0 V.

What is the energy transfer in the lamp over a period of 3.0 hours?

A 0.012 J
B 0.036 J
C 2.16 J
D 130 J

Your Answer

[1]

20. Power has base units kg m^2 s^{-3}.

What are the base units for intensity?

A kg s^{-3}
B kg ms^{-3}
C kg m^2s^{-3}
D kg m^4s^{-3}

Your Answer

[1]

21. Which set of prefixes **A**, **B**, **C** or **D** are in order of **increasing** magnitude?

A micro, milli, centi, kilo
B milli, centi, micro, kilo
C kilo, centi, milli, micro
D centi, micro, milli, kilo

Your Answer

[1]

22. Which pair of quantities have the same S.I. base units?

A force, energy
B moment, momentum
C power, work done
D work done, moment

Your Answer [ ]

[1]

23. What is the correct SI unit for acoustic impedance?

A kg s
B kg m^{-2} s^{-1}
C kg m^{-3} s^{-1}
D kg m^{-2} s^{-2}

Your Answer [ ]

[1]

24. Which of the following shows the correct base units for pressure?

A kg m^{-2}
B kg m^{-2} s^{-2}
C kg m^{-1} s^{-2}
D kg m^{2} s^{-3}

Your Answer [ ]

[1]

25. What is the de Broglie wavelength in nm of a proton travelling at 1.5×10^4 m s^{-1}?

A 2.6×10^{-2} nm
B 2.6 nm
C 49 nm
D 4.9×10^4 nm

Your Answer

[1]

26. What is the correct unit for specific heat capacity?

A. $m^2s^{-2}K^{-1}$
B. $ms^{-2}K^{-1}$
C. $m^2s^{-1}K^{-1}$
D. $m^2s^{-2}K$

Your Answer

[1]

27. Which pair of quantities have the same S.I. base units?

A force, strain
B force, stress
C pressure, stress
D strain, upthrust

Your Answer

[1]

28. The S.I. base units for the ohm (Ω) are kg m^2 s^{-3} A^{-2}.

Use the equation $R = \frac{\rho L}{A}$ to determine the S.I. base units for resistivity ρ.

base units for ρ .... **[2]**

29 (a). Fig. 2.1 shows an experiment in the laboratory to investigate the extension of two identical springs connected end to end. A student initially measures the length L of the two-spring combination without a load attached.

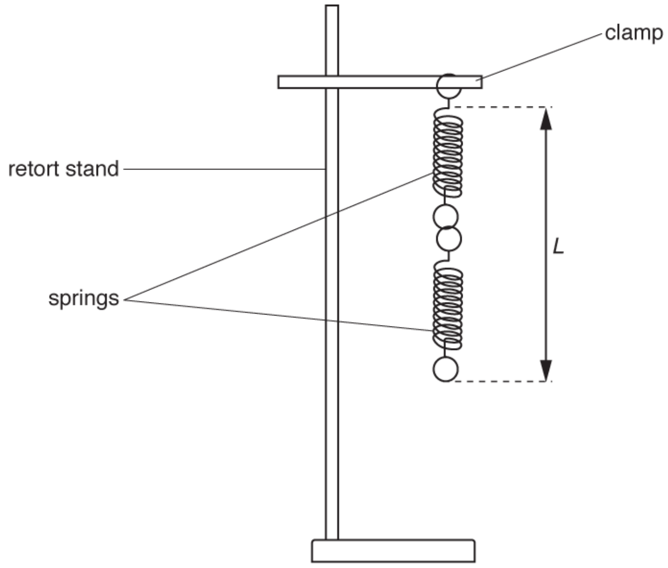


Fig. 2.1

The student adds mass m to the lower spring and measures the new length L of the two-spring combination.

The student determines the weight F of the mass added to the spring.

The student’s results are shown in Fig. 2.2.

m/g	*F*/N	*L*/cm	
0	0	12.0	
50	0.49	13.0	
100	0.98	13.8	
150	1.47	14.8	2.8
200	1.96	15.6	3.6
250	2.45	16.6	4.6

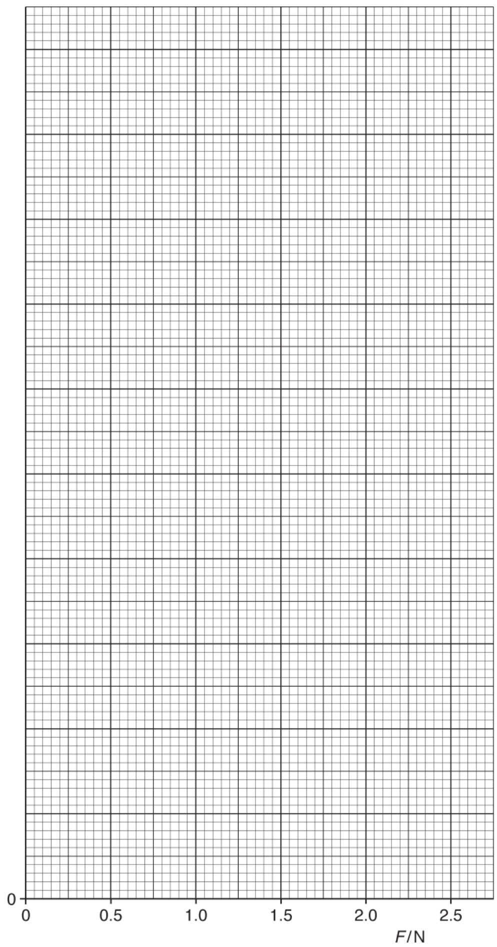
Fig. 2.2

Complete the table shown in Fig. 2.2 by calculating and recording values of the extension *e* / cm of the spring combination. **[1]**

(b).

On Fig. 2.3 plot a graph of *e* / cm (*y*-axis) against *F* / N (*x*-axis). Draw the straight line of best fit. **[4]**

Fig. 2.3



(c). Determine the gradient of the straight line of best fit.

gradient = ... **[1]**

(d). Use your answer to **(c)** to determine the experimental value for the force constant k_2 of the two-spring combination. Include an appropriate unit.

k_2 = ... **[2]**

(e). State and explain whether your graph shows that the spring combination obeys Hooke's law.

____

____

____

____ **[2]**

(f). The experiment is repeated with a third identical spring added to the bottom of the two springs. The force constant of this new three-spring combination is k_3.

Determine the ratio $\frac{k_3}{k_2}$.

$\frac{k_3}{k_2}$ = ... **[2]**

30. The Planck constant *h* is an important fundamental constant in quantum physics.

Determine the S.I. base units for *h*.

base units = ... **[2]**

31. Wind turbines convert the kinetic energy of the wind into electrical energy.
Fig. 18 shows a wind turbine.

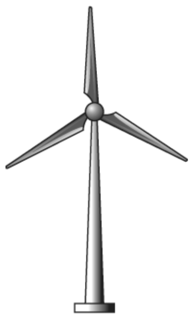


Fig. 18

When the wind speed is 8.0 m s^{-1}, the kinetic energy of the air incident at the turbine per second is 1.2 MJ s^{-1}.
Calculate the mass of the air incident at the turbine per second.

mass per second = -------------------------------------- kg s^{-1} **[2]**

32. What are the correct base units for work done or energy?

A kg m
B kg m s^{-2}
C kg m^2s^{-2}
D kg m^2s^{-2}

Your Answer [ ]

[1]

33. Derive the S.I. base units for resistance.

base units: ------------------------------------ **[2]**

34 (a).

A capacitor of capacitance 7.2 pF consists of two parallel metal plates separated by an insulator of thickness 1.2 mm. The area of overlap between the plates is 4.0×10^{-4} m^2. Calculate the permittivity of the insulator between the capacitor plates.

permittivity = ... F m^{-1} **[2]**

(b). Fig. 21 shows a circuit.

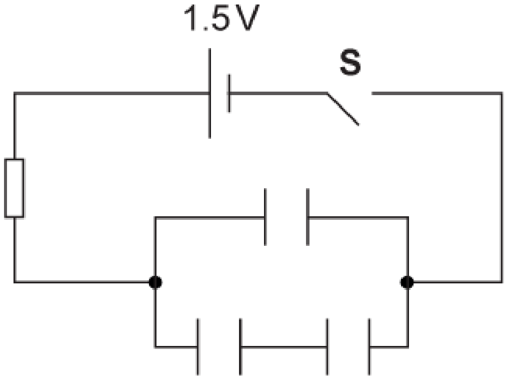


Fig. 21

The capacitance of each capacitor is 1000 μF. The resistance of the resistor is 10 kΩ. The cell has e.m.f. 1.5 V and negligible internal resistance.

i. Calculate the total capacitance *C* in the circuit.

C = ... μF **[2]**

ii. The switch **S** is closed at time $t = 0$. There is zero potential difference across the capacitors at $t = 0$. Calculate the potential difference *V* across the resistor at time $t = 12$ s.

V = ... V **[2]**

35 (a). Fig. 16 shows a hydraulic jack used to lift a car which has a mass of 1200 kg. A mechanic exerts a downwards force of 400 N on the handle of the jack, moving it 80.0 cm downwards. As he moves the handle, the car rises 2.0 cm.

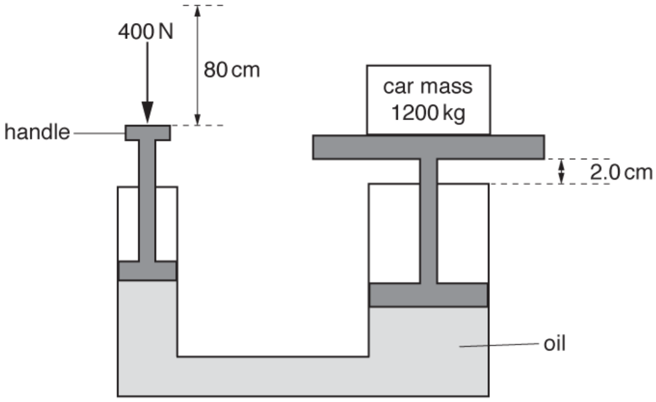


Fig. 16

Calculate the work done by the 400 N force exerted by the mechanic.

work done = ... J **[2]**

(b). Calculate the ratio: $\frac{\text{speed of handle moving down}}{\text{speed of car moving up}}$.

ratio = ... **[2]**

(c). Calculate the useful work done on the car and hence the percentage efficiency of the jack.

efficiency = ... % **[2]**

36. A student is designing a three-legged wooden stool as shown in Fig. 2.2.
The stool must be able to support the weight of an adult.

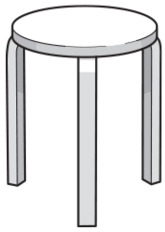


Fig. 2.2

The maximum compressive stress of the wood is 2.3 MPa.

Estimate the minimum cross-sectional area *A* of **one** leg.

A = ... m^2 **[3]**

37. An engineer is investigating the tension in a steel cable supporting a uniform wooden plank as shown in Fig. 4.

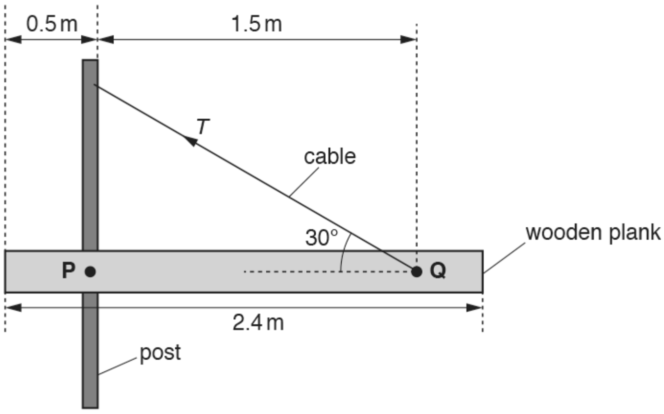


Fig. 4 (not to scale)

The plank is 2.4 m long and has a mass of 50 kg. It is pivoted at point **P** to a vertical post. The cable is fixed to the plank at point **Q** and to the vertical post as shown in Fig. 4. The cable is at an angle of 30° to the plank. The plank is in equilibrium and resting in a horizontal position.

The original length of the steel cable is 1.73 m and it has a cross-sectional area of 11.0 mm^2.
The Young modulus of steel is 210 GPa.
Calculate the extension x of the cable shown in Fig. 4.

x = m **[3]**

38. In Fig. 18.1 the solid line represents the displacement s against distance x graph for a **progressive** transverse wave on a stretched string at time t = 0. The dotted line shows the graph for the same wave at a later time t = 2.5 ms.

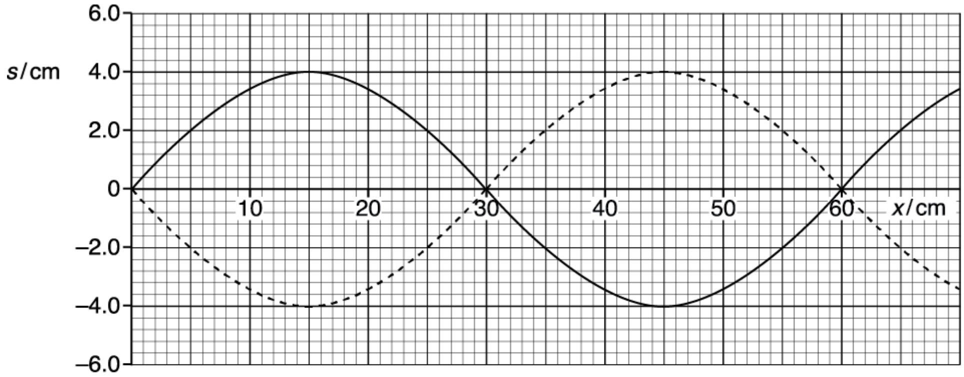


Fig. 18.1

Determine the frequency f of this wave.

f =.. Hz **[3]**

39. The wavelength of light from an LED is 480 nm. The radiant power emitted from the LED is 1.2 mW. Calculate the number of photons *N* emitted from the LED per second.

N = ... s^{-1} **[3]**

40. The unit of potential difference is the volt.

Use the equation $W = VQ$ to show that the volt may be written in base units as kg m^2 A^{-1} s^{-3}.

[3]

41. Fig. 26.1 shows an arrangement used to demonstrate a particular wave phenomenon.

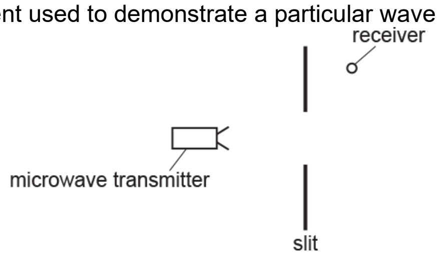


Fig. 26.1

A metal sheet with a wide slit is placed between a microwave transmitter and a receiver. The microwaves have a frequency of 11 GHz.

i. Calculate the wavelength λ of the microwaves.

λ = m **[1]**

ii. The receiver detects no microwaves in the position shown in Fig. 26.1.
The metal sheet is replaced by another sheet with a narrow slit of width of a few centimetres, as shown in Fig. 26.2. The positions of the transmitter, receiver and the metal sheet are unchanged.

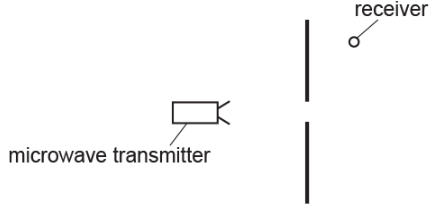


Fig. 26.2

Explain why the receiver now detects microwaves.

[2]

42. Fig. 22.2 shows an arrangement used to investigate how the kinetic energy of a toy car varies with its distance *d* from the top of the ramp.

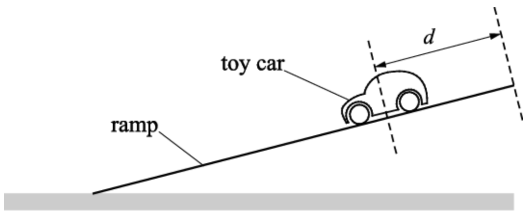


Fig. 22.2

The toy car is released from rest from the top of the ramp. The two graphs in **Fig. 22.3** show the variation of the gravitational potential energy E_p of the toy car and its kinetic energy E_k with distance *d* from the top of the ramp.

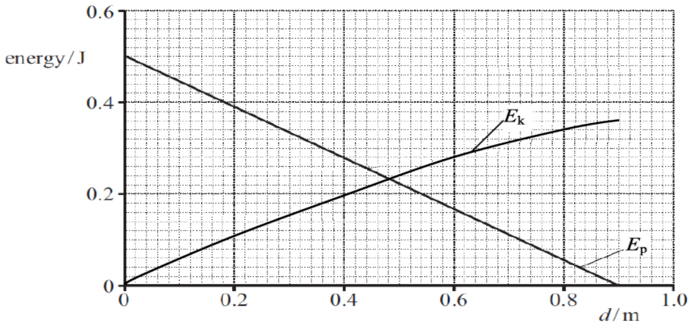


Fig. 22.3

The car travels a distance of 90 cm along the length of the ramp.

i. The variation of E_p with *d* is linear.
State why the E_k against *d* graph is **not** linear.

[1]

ii. Use **Fig. 22.3** to determine the average resistive force acting on the toy car.

force = ...N **[2]**

43. Describe and explain how you could make use of standard laboratory equipment to determine the mass per unit length μ of a wire. State how you would make your results as precise and accurate as possible.

[3]

44. Microwaves and X-rays are examples of electromagnetic waves.

i. The following are possible wavelengths of electromagnetic waves.

0.2 km 2 m 2 cm 0.2 mm 2 μm 200 nm 200 pm

Select from the list above a typical wavelength of a microwave and an X-ray.

Microwave ____

X-r____________________________

[2]

ii. One property of electromagnetic waves is that they are transverse waves.

State **two** other properties.

1.

2.

[2]

45. A student is investigating an unidentified component found in the laboratory.
The table shows the results from the lab book of the student.

V / V	**I / mA**
− 5.0	− 5.0
+ 5.0	+ 5.0
+ 10.0	+ 30.0

The potential difference across the component is *V* and the current through it is *I*.

i. Calculate the power dissipated by the component when *V* is +10.0 V.

power = W **[1]**

ii. Analyse the data in the table and hence identify the component.

[3]

46. Fluorodeoxyglucose (FDG) is a radioactive tracer often used for PET scans. It contains radioactive fluorine-18, which is a positron-emitter. Some information about FDG and fluorine-18 is given below.

- 9.9% of the mass of FDG is fluorine-18.
- The half-life of fluorine-18 is 6600 s.
- The molar mass of fluorine-18 is 0.018 kg mol^{-1}.

A patient is injected with FDG. The initial activity of FDG is 400 MBq.

Use the information given to calculate the initial mass of FDG given to the patient.

mass = ... kg **[4]**

47. A patient with a blood clot in his muscle is having an ultrasound A-scan.
Fig. 24.1 shows an ultrasound transducer placed on the patient's skin.

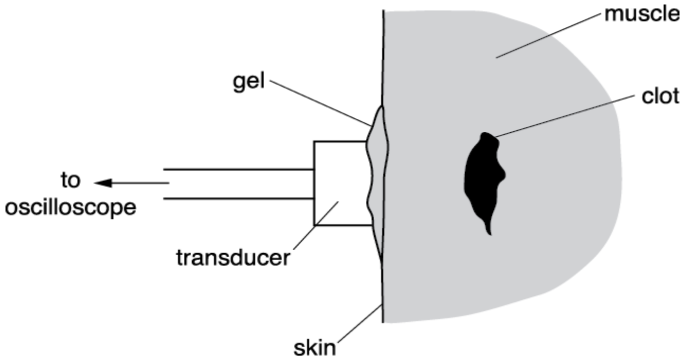


Fig. 24.1 (not to scale)

The ultrasound transducer produces pulses of ultrasound. An oscilloscope is connected to the transducer. Fig. 24.2 shows part of the oscilloscope display.

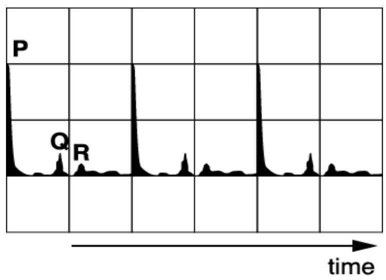


Fig. 24.2

The **front** of the blood clot is 1.5 cm from the skin.
The density of the patient's muscle is 1070 kg m^{-3}.
The time difference between pulses **P** and **Q** in Fig. 24.2 is 19 μs.

Determine the acoustic impedance Z of patient's muscle. State an appropriate unit for your answer.

Z = ... unit: .... **[4]**

48 (a). A loudspeaker emits a sound wave. A microphone is connected to an oscilloscope. The trace produced on the screen of the oscilloscope due to the sound wave is shown in Fig. 1.

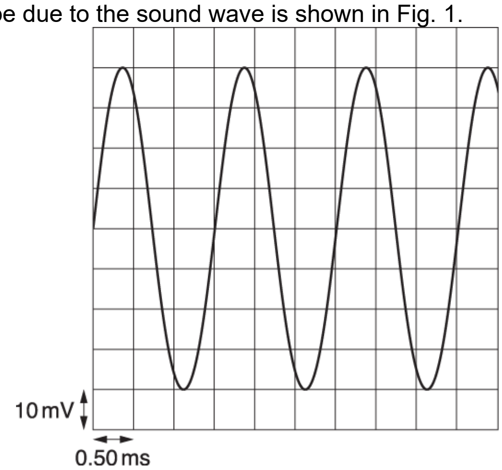


Fig. 1

The vertical y-sensitivity of the oscilloscope is set to 10 mV div^{-1} and the horizontal time-base is set to 0.50 ms div^{-1}.

i. Determine the amplitude of the signal displayed on the oscilloscope.

amplitude = ... mV **[1]**

i. The frequency f of the sound wave is the same as the frequency of the signal shown in Fig. 1. Determine f.

f = ... Hz **[2]**

ii. The speed of sound in air is 330 m s^{-1}. Calculate the wavelength λ of the sound wave.

λ = ... m **[1]**

(b). The output from the loudspeaker is adjusted so that the **intensity** of the sound wave at the microphone is a quarter of its original value. The controls on the oscilloscope are not altered.

Describe and explain how the signal displayed on the oscilloscope will be different from Fig. 1.

[2]

49. Electromagnetic radiation of wavelength 300 nm is incident on the surface of two metals **X** and **Y**. Metal **X** has work function 2.0 eV and metal **Y** has work function 5.0 eV.

With the help of calculations, explain any difference between the emission of photoelectrons from the surfaces of the metals **X** and **Y**.

[4]

50. The diagram below shows a beam of X-rays incident normally on some soft tissue.

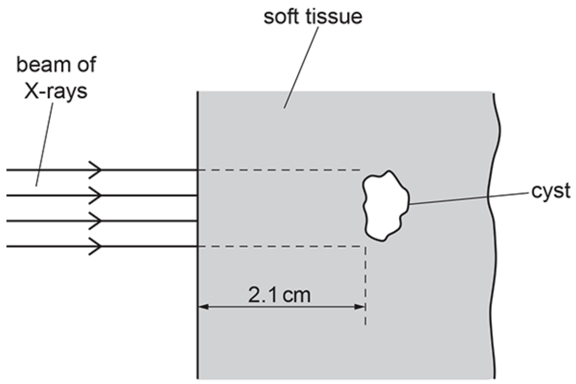


Fig. 2

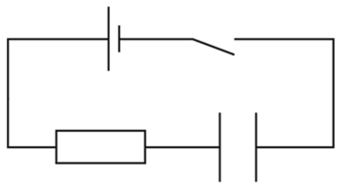
The attenuation (absorption) constant of the soft tissue is 0.85 cm^{-1}.
The intensity of the beam is 4.6×10^3 W m^{-2}.
There is a small cyst 2.1 cm from the surface of the soft tissue. The cross-sectional area of the cyst normal to the beam is 3.4×10^{-4} m^2.

The beam is switched on for 30 s.

Calculate the X-ray energy incident on the cyst in a period of 30 s.

energy = ... J **[4]**

51. The diagram below shows a circuit to charge a capacitor.



The electromotive force (e.m.f.) *E* of the cell is 1.48 V and it has negligible internal resistance.
The resistance of the resistor is 120 kΩ and the capacitance of the capacitor is 2000 μF.
At time *t* = 0 the capacitor is uncharged.
The switch is closed at time *t* = 0.

Calculate the time *t* when the potential difference across the capacitor is 1.00 V.

t = ... s **[4]**

52. The normal frequency range of hearing for young people is from 20 Hz to 20 kHz.

i. The speed of sound in air is 340 m s^{-1}.

Calculate the **shortest** wavelength a young person can hear.

wavelength = ... m **[2]**

ii. Describe how you can use an oscilloscope, and other additional laboratory equipment, to determine the actual upper limit of the frequency range for a young person.

[3]

53. Procyon is a star of radius 1.4×10^9 m. The total output power of the electromagnetic radiation from its surface is 2.7×10^{27} W. The average wavelength of the electromagnetic waves from Procyon is 5.0×10^{-7} m.

i. Show that the surface intensity of the radiation from Procyon is 1.1×10^8 W m^{-2}.

[2]

ii. Calculate the energy of a photon of wavelength 5.0×10^{-7} m.

energy = J **[2]**

iii. Estimate the total number of photons emitted per second from the surface of Procyon.

number per second = s^{-1} **[1]**

54. The Big Bang theory explains the origin and the evolution of the early Universe.
The table below shows the distance *d* and recession velocity *v* of some galaxies close to our own galaxy.

Galaxy	***d* / Mpc**	***v* / km s^{-1}**
NGC-5357	0.45	200
NGC-3627	0.90	650
NGC-4151	1.7	960
NGC-4472	2.0	850

The chemical composition of the stars in our galaxy can be determined by analysing in the laboratory the absorption spectral lines for these stars.

The closest star to us is the Sun.

The wavelength of the hydrogen-beta spectral line from the Sun is 486 nm.

i. Use the information from the table to calculate the **observed** wavelength λ of the hydrogen-beta spectral line from a star in the galaxy NGC-4151.

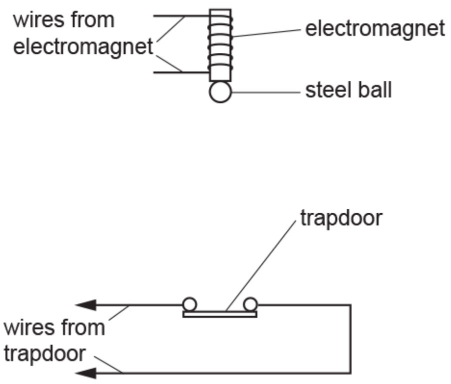
λ = ... nm **[3]**

ii. A diffraction grating with 800 lines per mm is used to observe and analyse the light from the Sun in the laboratory.
A narrow beam of light from the Sun is incident normally at the diffraction grating.
Calculate the angle θ between the central beam of light through the grating and the hydrogen-beta spectral line in the **second** order spectrum.

θ = ... ° **[2]**

55. A student wants to determine the value of the acceleration of freefall *g*.

The diagram below shows part of the arrangement which the student used.



A steel ball is dropped from an electromagnet. The ball falls vertically. The ball hits a trapdoor and opens the trapdoor.
The ball travels a distance s from the bottom of the electromagnet to the trapdoor in a time *t*.

The student uses the equation $s = \frac{1}{2}gt^2$ to determine *g*.

i. Show that the equation $s = \frac{1}{2}gt^2$ is homogeneous, with both sides of the equation having the same base units.

[2]

ii. Describe how the student could use standard laboratory equipment to take accurate measurements of the distance s and the time *t*.

[4]

56. Fig. 24 shows two horizontal metal plates in a vacuum.

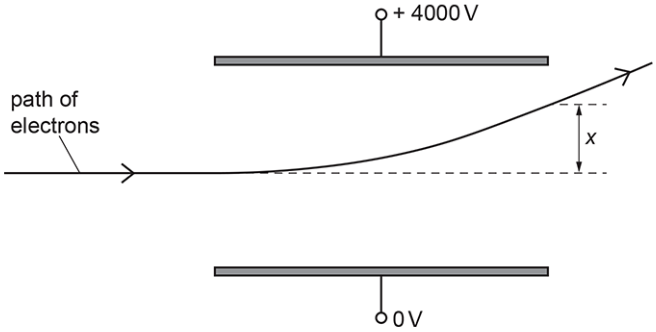


Fig. 24

The diagram is **not** drawn to scale.
Electrons travelling horizontally enter the space between the charged plates and are deflected vertically.

The potential difference between the plates is 4000 V.
The distance between the plates is 0.08 m.
The initial speed of the electrons is 6.0×10^7 m s^{-1}.
The vertical deflection of the electrons at the far end of the plates is x.

i. Show that the vertical acceleration a of an electron between the plates is 8.8×10^{15} m s^{-2}.

[3]

ii. The length of each plate is 0.12 m.

Show that the time *t* taken by the electron to travel this length is 2.0×10^{-9} s.

[1]

iii. Calculate the vertical deflection x of the electron.

x = ... m **[2]**

57. Some nuclear fission reactors use uranium-235 as fuel. In the future, there is possibility of using hydrogen-2 as fuel in fusion reactors.

Here is some information and data on fission and fusion reactions.

	Fission reactor	**Fusion reactor**
Typical reaction	${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n$	${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H$
Approximate energy produced in each reaction	200 MeV	4 MeV
Molar mass of fuel material	uranium-235: 0.235 kg mol^{-1}	hydrogen-2: 0.002 kg mol^{-1}

- Describe the similarities and the differences between fission and fusion reactions.
- Explain with the help of calculations, which fuel produces more energy per kilogram.

[6]

58. This question is about a space probe which is in orbit around the Sun.

The power source for the instrumentation on board the space probe is plutonium-238, which provides 470 W initially.

Plutonium-238 decays by α-particle emission with a half-life of 88 years.
The kinetic energy of each α-particle is 8.8×10^{-13} J.

i. Calculate the number N of plutonium-238 nuclei needed to provide the power of 470 W.

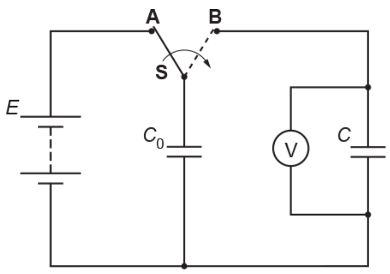
N = ...**[3]**

ii. Calculate the power P still available from the plutonium-238 source 100 years later.

P = ... W **[3]**

59 (a). The diagram below shows a circuit containing two capacitors which are both initially uncharged. The battery has e.m.f. *E* and negligible internal resistance.

The switch **S** is first moved to position **A** until the capacitor of capacitance C_0 is fully charged.



The switch **S** is then moved to position **B**. The initial charge stored by the capacitor of capacitance C_0 is shared between the two capacitors.
The final reading on the voltmeter is *V*.

Show that . $V = \frac{C_0}{C + C_0} E$

[2]

(b). A student wants to determine the values of E and C_0 by repeating the experiment above and measuring the potential difference (p.d.) V for a selection of capacitors of capacitance C.

The student decides to plot a graph of $\frac{1}{V}$ against C.

i. Use the expression in **(a)** to show that the graph should be a straight line of gradient $\frac{1}{C_0 E}$ and *y*-intercept $\frac{1}{E}$.

[1]

ii. The data points, error bars and the line of best fit drawn by the student are shown in the graph below.

The gradient of the line of best fit is 51 V^{-1} F^{-1}. The value of E is 9.1 V.

Determine the value of C_0 in millifarads (mF). Write your answer to 2 significant figures.

C_0 = ... mF **[2]**

iii. Draw on the graph a straight line of worst fit.

Use this line to determine the absolute uncertainty in your value of C_0. Write your answer to an appropriate number of significant figures.

absolute uncertainty = ... mF **[4]**

(c). The experiment is repeated with a resistor of resistance 10 kΩ placed in series between **S** and the capacitor of capacitance C_0.

State with a reason what effect, if any, this would have on the experiment.

[1]

60. Fig. 19 shows a crane lifting a car of mass 850 kg at constant velocity through a height of 12 m in a time of 40 s. The crane has a working efficiency of 60 %.

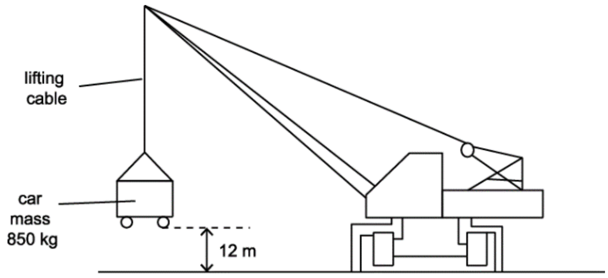


Fig. 19

i. Calculate the tension in the lifting cable.

tension = ...N **[1]**

ii. Calculate the total input power required by the crane to lift the car.

total input power = ...W **[4]**

iii. Suggest and explain **two** ways the crane can be modified to improve its efficiency.

[2]

61. Hubble's law can be used to estimate the age of the universe. Fig. 23 shows some of Hubble's early measurements of nearby galaxies plotted on a *v* against *d* graph, where *v* is the recessional speed of a galaxy and *d* is its distance from us.

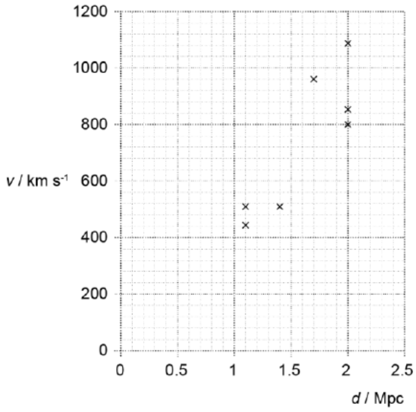


Fig. 23

i. State how *v* was determined.

[1]

ii. Use Fig. 23 to estimate a value for the Hubble constant H_0 in km s^{-1} Mpc^{-1}.

H_0 = ...km s^{-1} Mpc^{-1} **[3]**

iii. Use your answer to part **(ii)** to estimate Hubble's initial value for the age of the universe in years.

age = ...years **[3]**

62. The work function of potassium is 2.3 eV.

i. Potassium emits electrons from its surface when blue light is incident on it. Extremely intense red light produces no electrons.

Explain these observations in terms of photons and their energy.

[4]

ii. Light from a laser is incident on some potassium in a vacuum. Electrons are emitted. The wavelength of the light is 320 nm.

Calculate the shortest de Broglie wavelength of the emitted electrons.

de Broglie wavelength = ... m **[4]**

63 (a). A student measures the diameter of a ball in different directions.

The student's results are:

2.43 cm 2.54 cm 2.59 cm

i. State the name of a suitable measuring instrument to measure the diameter of the ball.

[1]

ii. Calculate the mean diameter *d* of the ball.
Include the absolute uncertainty in *d*.

d = ... ± .... cm **[2]**

iii. Show that the volume of the ball is about 8.4×10^{-6} m^3.

[1]

iv. The mass of the ball is 23 ± 1 g.
Determine the density ρ of the ball.
Give your answer to an appropriate number of significant figures.

ρ = ... kg m^{-3} **[2]**

v. Determine the percentage uncertainty in ρ.

percentage uncertainty = ... % **[2]**

(b). The 23 g mass ball from **(a)** is used in an experiment with a spring.

The student measures the unstretched length L_0 of a spring as shown in Fig. 3.1.

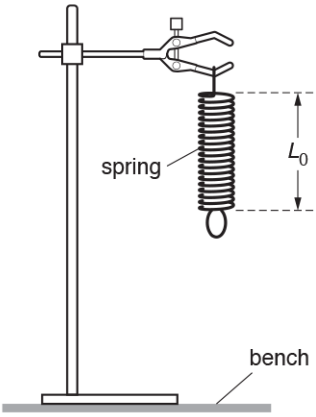


Fig. 3.1

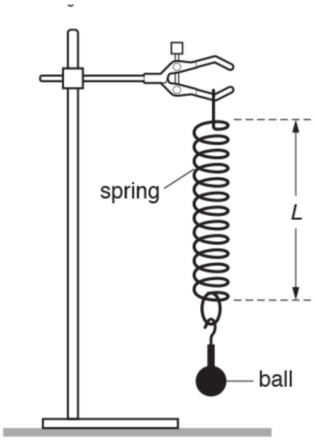


Fig. 3.2

The student then attaches the ball to the spring and measures the length L of the spring as shown in Fig. 3.2.

The student's results are:

L_0 = 0.078 m and L = 0.096 m

Calculate the force constant k of the spring.

k = ... N m^{-1} **[3]**

(c). The 23 g mass ball from **(a)** and the spring from **(b)** are now used in an experiment to investigate upthrust.

The ball attached to the spring is lowered into a beaker containing a liquid so that it is totally submerged. The student measures the new length L_N of the spring, as shown in Fig. 3.3.

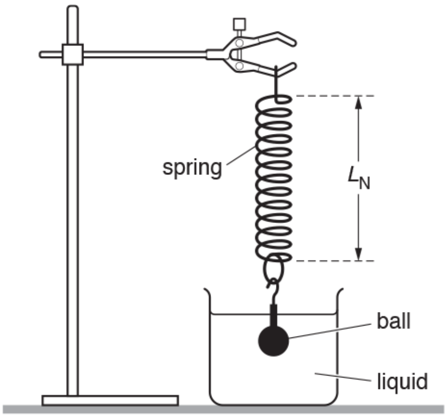


Fig. 3.3

The length L_N of the spring is now 0.088 m.

i. Calculate the upthrust on the submerged ball.

upthrust = ... N **[2]**

ii. Calculate the density of the liquid.

density of liquid = ... kg m^{-3} **[2]**

64. Fig.16 shows typical thinking, braking and stopping distances for **cars** driven at different initial speeds. The speed is shown in miles per hour (mph).

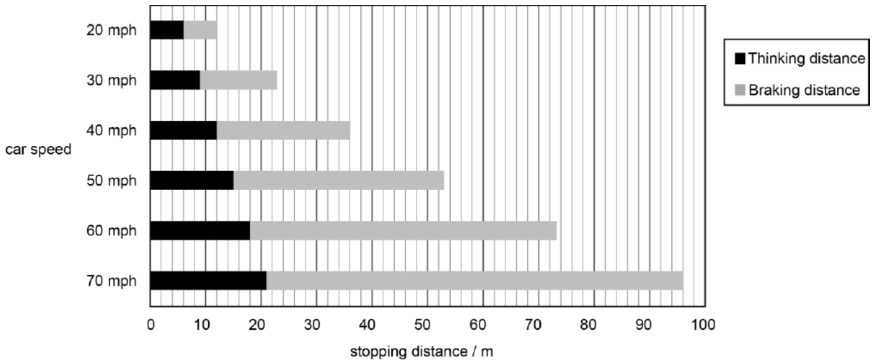


Fig. 16

A **truck** of mass 2300 kg is travelling at a constant speed of 22 m s^{-1} along a dry, level road. The driver reacts to a hazard ahead and applies the brakes to stop the truck. The reaction time of the driver is 0.97 s. The brakes exert a constant braking force of 8700 N.

i. Calculate the magnitude of the deceleration of the truck when braking.

deceleration = ...m s^{-2} **[2]**

ii. Show that the stopping distance of the truck is about 85 m.

[3]

iii. Show that a speed of 22 m s^{-1} is equivalent to about 50 mph (miles per hour). 1 mile = 1600 m

[1]

iv. Use Fig. 16 and your answer to (**ii**) to compare the stopping distance of the car and the truck at 50 mph. Suggest relevant factors that may have affected the stopping distance of the truck.

[4]

65. Fig. 1.1 shows a train of mass 1.9×10^5 kg travelling at 61 kmh^{-1} along a level track.

Fig. 1.1

i. Show that the train is travelling at about 17 ms^{-1}.

[1]

ii. The brakes of the train are applied and the train is brought to rest in a distance of 310 m. Calculate

1. the initial kinetic energy E_k of the train

E_k = ... J **[2]**

2. the average deceleration a of the train

a = ... ms^{-2} **[3]**

3. the average braking force F on the train.

F = ... N **[2]**

iii. Fig. 1.2 shows a similar train travelling at 61 kmh^{-1} up an incline.

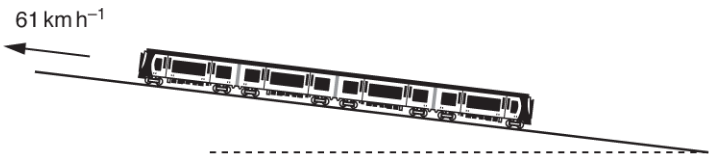


Fig. 1.2

The brakes of the train are applied with the **same** average braking force.
State and explain how the distance that the train travels, from when the brakes are applied until the train stops, compares with when the train is travelling on level track.

[2]

END OF QUESTION PAPER