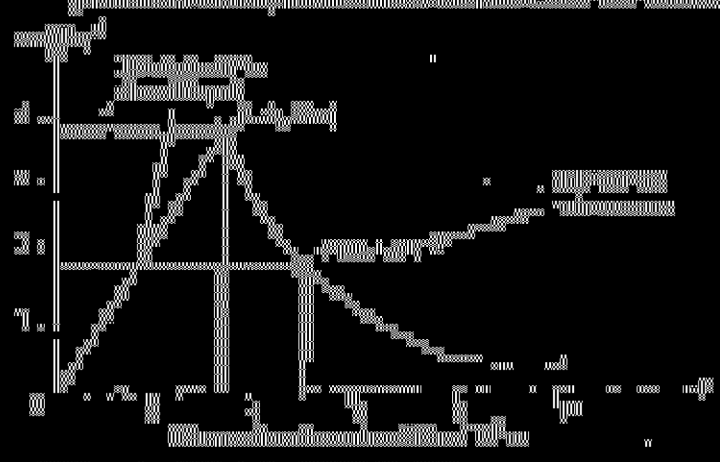
JC2 2003 Term 3 Common Test solutions



27 Use the following physical data for ice, water and steam (when necessary) to answer this question:

	Ice	Water	Water	Steam
Temperature	0 °C	0 °C	100 °C	100 °C
Volume occupied by 1 kg at standard pressure/ m^3	0.00109	0.00100	0.00104	1.67
Kinetic energy of all the molecules in 1 kg/ 10^5 kg	1.89	1.89	2.58	2.58
Potential energy of all the molecules in 1 kg (referred to ice at 0 °C)/ 10^5 J	0	3.36	3.41	24.3
Internal energy of 1 kg/ 10^5 J	1.89	5.25	5.99	26.9

(a) Explain why there is no change in the kinetic energy of the molecules when the ice at 0 °C changes to water at 0 °C. [1]

It is because kinetic energy of the molecules depends on the thermodynamic temperature. As there is no change in temperature during change of phase, hence no change in kinetic energy of the molecule.

Comments:
Most students explained using the idea that the energy supplied is used to overcome the intermolecular forces but did not proceed to explain that the energy supplied goes to increase the potential energy of the system, and not the kinetic energy.

(b) Complete the table for the internal energy of the substance. [2]

Comments:
Most students were able to complete the table, showing an understanding that the internal energy is given by the sum of the kinetic energy and potential energy of all the molecules.

(c) Determine the specific latent heat of fusion of ice. [2]

Change in internal energy of 1 kg of substance
$= (5.25 - 1.89) \times 10^5$
$= 3.36 \times 10^5$ J
Change in volume is negligible from 0 °C of ice to °C of water, so no work is done on the substance.
Hence, the specific latent heat of fusion of ice is 3.36×10^5 Jkg^{-1}.

Comments:
1. A few students misinterpreted the term 'determine' and instead defined the specific latent heat of fusion of ice.
2. Students were rather slipshod in their working and some did not show clearly that the mass of ice involved is 1 kg.
3. Several students gave a wrong unit to the specific latent heat of fusion.

(d) Calculate how much work has to be done by 1 kg of water in order to change to steam at 100 °C and at atmospheric pressure of 1.01×10^5 Pa. [2]

Change in volume = 1.67 – 0.00104 = 1.66896 m^3
Work done by 1kg of water = $p\Delta V$
$= 1.01 \times 10^5 \times 1.66896$
$= 1.69 \times 10^5$ J

Comments:
1. Students were very unclear in their presentation, with many losing marks because they did not indicate clearly what their 'work done' means. A very large number of students used the symbol 'w', without showing clearly what is meant by this symbol.
2. There was a handful of students who showed understanding of the importance of the term 'by' and 'on' and gave clear solutions.

27 (e) (i) State First Law of Thermodynamics. [1]

First Law of Thermodynamics states that the **increase** in the internal energy of a system is the **sum** of the work done on the system and the heat supplied to the system.

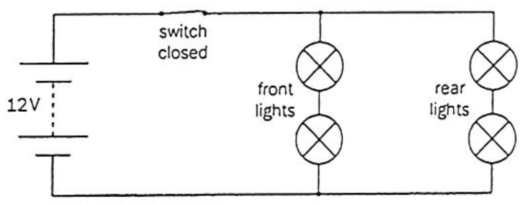
Comments:
1. Many students included the statement that 'the internal energy is dependent only its state'. This part is really not necessary in the statement of first law of thermodynamics.
2. Common mistakes include
   - Use of the term 'change' instead of 'increase'
   - Forgetting the word 'sum'
3. Most students, however, showed that they do remember that the term work done here is on the system and heat is supplied to the system.

(ii) Use the first law of thermodynamics to calculate the specific latent heat of vaporisation of water. [2]

For 1 kg of water, $\Delta U = (26.9 - 5.99) \times 10^5 = 20.91 \times 10^5$ J
$w = -1.69 \times 10^5$ J
Using $\Delta U = q + w$
$20.91 \times 10^5 = q + (-1.69 \times 10^5)$
$q = 2.26 \times 10^6$ J
therefore, the specific latent heat of vaporisation of water is 2.26×10^6 Jkg^{-1}

Comments:
1. Students who did not pay attention to whether it is work done on or by the system usually landed themselves in substituting the wrong value for w in the equation $\Delta U = q + w$.
2. Some students were rather careless and forgot the power of 10^5 for the values of internal energy, even though they have substituted the correct values for part (c).

28 A designer uses the circuit shown for the sidelights of a car. The lamps are each rated at 6 V, 12 W. The battery used is of negligible resistance.



(a) Calculate the current in the battery. [3]
The lights are operating normally since they have the same resistance and p.d. across each bulb is 6.0 V,
$I = P/V = 2.0$ A
$I_{battery} = I_B + I_C = 4.0$ A

Comments:
1. Several students did not show the working clearly and lost mark as a result.
2. Many students who used the above approach did not show clearly that the bulbs are operating normally. It is important to show that the p.d. across each bulb is 6.0 V.
3. Another approach is to determine the resistance of each bulb, find the effective resistance of the circuit before determining the current.

28 (b) A fully charged battery is able to supply a total charge of 1.2×10^5 C. How long could the lamps operate when connected to a fully charged battery? [1]

$Q = I \times t$
$t = 1.2 \times 10^5/4 = 3.0 \times 10^4$ s

Comments:
1. Most students were able to solve this part, except for some who remembered the equation wrongly.
2. Some students, on seeing the term charge, stated the equation Q = CV and hence unable to continue at all. They did not seem to realise that Q = CV is only applicable to capacitance question.

(c) A user replaces one of the front lamps with one rated at 12 V, 24W. State and explain whether
(i) the **front** sidelights will operate at their normal rated power, [2]

No. P.d. across the lamps are 4V and 8V, or current through the lamps to be 1.33A respectively, and show that they are below the rated voltage or current needed. Or power dissipated to be 5.3W and 10.6W respectively, or state that 18V is needed for both lamps to operate at their rated power, but the battery only supplies 12V.

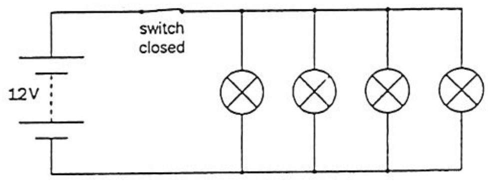
Comments:
Some students determined I thru' the battery as 3.33A and say its higher than the 2.0A needed. This is not an acceptable approach as it doesn't mean that the current through the branch would not be 2.0A.

(ii) the change has any effect on the brightness of the **rear** sidelights. [2]

No. P.d. across or current through the lamps are still the same.

Comments:
No credit for merely stating that the lamps are connected in parallel without further explanation.

(d) The original circuit is not normally used. In practice, four lamps, each rated at 12 V, are connected in parallel as shown below. Suggest why this is preferred. [1]



28(d) When one of the lamp blows, the other 3 lamps will still operate and it will be easy to identify the faulty lamp.

Comments:
A common wrong answer is that the total resistance of the circuit will be smaller and the power or current needed will be smaller. Some also think that when a lamp blows, it becomes short circuited when it is actually open circuit.

29 An ideal operational amplifier (op-amp) is used in the circuit shown in Fig 29.1. The input potential is $V_{in} = -1.0$ V and the power supply for the amplifier is provided by two batteries, each of emf 15 V and zero internal resistance.

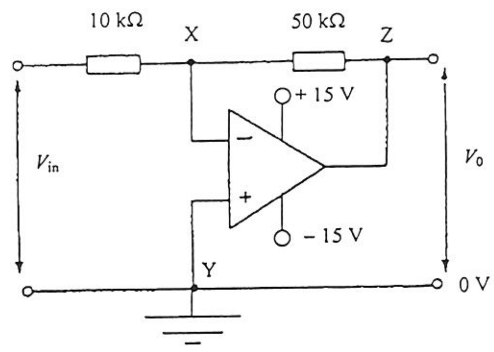


Fig 29.1

(a) State **TWO** properties of an ideal op-amp. [2]
a. infinite input impedance
b. infinite open-loop gain
c. zero output impedance
d. infinite bandwidth
e. infinite slew rate (any 2)

This part is well-answered.

(b) Briefly explain why point *X* is said to be "*virtually earthed*". [1]

If output not saturated,
$V^- \approx V^+$ have same potential / voltage

A lot of students did not mention the necessary condition, ie. output not saturated.

(c) (i) Find the current flowing through the 10 kΩ resistor and state its direction of flow. [2]

$I = \frac{0-(-1)}{10} = 0.10$mA, toward left

Most can answer. Some students drew the direction instead of stating.

(ii) Determine the current flowing through the 50 kΩ resistor [1]

(same) 0.10 mA

Well-answered.

29 (d) What is the output potential V_0? [2]

$I = \frac{V_o - 0}{50} = 0.1$; or $\frac{Vo}{Vin} = -\frac{50}{10}$

Vo = 5.0 V

Well-answered.

(e) V_{in} is replaced by a sinusoidal-wave voltage which varies between – 5.0 V and + 5.0 V as shown in Fig 29.2. Sketch on the same axes, the variation of the output potential V_0, with time, t. Label your graph V_0. [3]

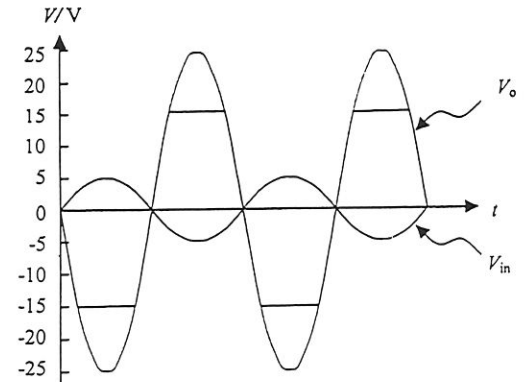


Fig. 28.2

Most students are able to draw correctly. Mistakes commonly made are:
1. Output not inverted.
2. Output saturates immediately, rather than having a gain of 5.
3. Output not clipped at ± 15V

30 An alternating current varies with time in the way shown in Fig. 30.1

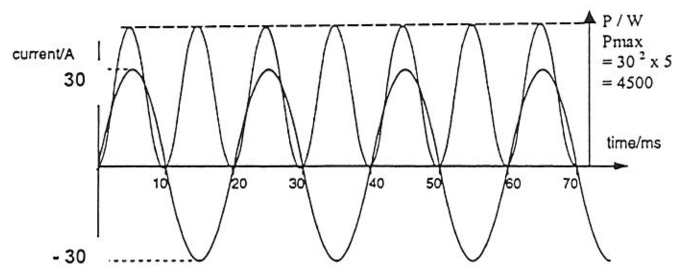


Fig. 30.1

(a) Use the graph to determine,
(i) the frequency [1]

$f = \frac{1}{20\times10^{-3}} = 50$ Hz

Well-answered.

30 (ii) the root-mean-square value. [1]

$I_{rms} = \frac{30}{\sqrt{2}} = 21.2$ A

Well-answered. The most common mistake is multiplying instead of dividing 30 with $\sqrt{2}$.

(b) On Fig. 30.1 sketch a graph which shows how the power supplied by this current to a resistor of resistance 5.0 Ω varies with time. Label the vertical axis as power and mark on this axis the maximum value of the power. [2]

Most students did not draw a smooth curve at the horizontal axis. Some calculated the maximum power but did not mark its value on the axis.

(c) The current shown in Fig 30.1 is the input current in the 300 turn primary of an ideal transformer. The secondary of the transformer has 6000 turns.
(i) Calculate the transformer's peak output current. [1]

Many students did well in this question. Common mistakes made are:
1. They did not show the values used in their substitution.
2. The haves problem manipulating the equation.
3. The used 600 turns instead.

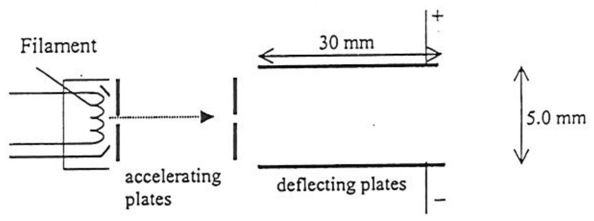
(ii) A generator produces the current shown in Fig 30.1 at 400 V rms. The voltage is stepped up using the above transformer before the power is transmitted over a distance of 1.0 km through a power line of total resistance 50 Ω.
1 Determine the percentage of power loss in the transmission. [3]

This question was poorly done. Not many students obtain the full marks.
Common mistakes are:
1. They used the peak current of 1.5 A to calculate the mean power loss.
2. They mixed peak values with rms values in the calculations.
3. They used maximum power in their calculation without realising it or stating it.
4. Used the formula Power loss formula, $[P_{gen}/V_{in}]^2$ R blindly without understanding.
5. Use of V^2/R without understanding.

2 If the electricity cost $0.50 per kilowatt hour, estimate the cost due to power loss in the transmission for one day. [2]

This question is just simple reading of the given questions and and putting into the computation. Students tried to recall some methods from tutorial or lecture notes by multiplying some numbers (eg. 60x 60, 1000) and hoping to get it correct. Many students fail to convert the power loss to kilowatt before further evaluation.

31



Electrons in a cathode ray tube are accelerated from rest to a speed of 2.0 x 10^7 ms^{-1}, travelling horizontally before passing between two horizontal deflecting plates that are 5.0 mm apart and 30 mm long. The potential difference applied across the deflecting plates is 60 V.

(a) Calculate
(i) the potential difference across the accelerating plates [2]

Generally well done. Common errors are:
1. Students could not recall the formula for the gain in KE to the loss in EPE. They equated eE = ½ mv^2.
2. Some students resort to kinematics to solve. They fumbled at the point where they used the distance between the two plates d in d/t as velocity. They should have considered acceleration in their computation.
3. A large number of students made sf mistakes here.
4. Many gave the answers without showing working.

(ii) the speed of an electron after passing through the deflecting plates. [3]

$a_y = F_y / m_e = eV / m_e d = 2.11 \times 10^{15}\ ms^{-2}$

$s_x = u_x t$
$t = 30 \times 10^{-3} / 2.0 \times 10^7 = 1.5 \times 10^{-9}$ s

$v_y = u_y + a_y t$
$= 0 + (2.11 \times 10^{15})(1.5 \times 10^{-9})$
$v_y = 3.17 \times 10^6\ ms^{-1}$

$v = \sqrt{(v_x^2 + v_y^2)}$
$= 20.2 \times 10^6\ ms^{-1}$

Comments
Many used $\frac{1}{2}mv^2 = q\Delta V$ or $v^2 = u^2 + 2as$ for this part. No credit given as it is a wrong assumption that the electrons will move vertically through the whole or half the distance between the two plates.
Many committed sf error by writing 1.5×10^{-9} as 1×10^{-9}, probably because their Sharp calculator did not show the 11th digit.

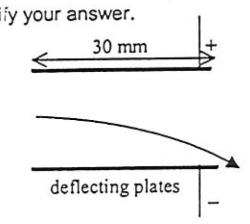
31(b) With the deflecting voltage maintained at 60 V, a magnetic field is applied between the deflecting plates so that the electrons are undeflected.
(i) Determine the magnitude and direction of the magnetic flux density of the field. [3]

When electrons are undeflected,
$F_m = F_e$
$Bev_x = eV/d$
$B = V / v_x d$
$= 60 / (2.0 \times 10^7) \times (5.0 \times 10^{-3})$
$= 6.0 \times 10^{-4}$ T

The magnetic field is directed into the paper.

Comments
Some students are confused between $q\Delta V$ and qE. Some substituted the v_y instead of v_x for $F_B = Bev$.

(ii) If both fields at the deflecting plates are kept at these constant values, sketch the probable path of the electrons when the potential difference across the accelerating plates is increased. Justify your answer. [2]



If pd across accelerating plates is increased, the electrons will enter the deflecting plates with a larger horizontal velocity. This will cause an increase in the magnetic force on the electrons. Therefore, electrons will be deflected downwards.

Comments
Some students mistook pd across deflecting plates to increase when it was actually the pd across the accelerating plates that was increased. And therefore concluded that the E-field in the deflecting plates will increase causing electrons to be deflected upwards!

Section B Physics of Fluids (Answer all the questions on writing paper)
(You are advised to spend not more than 20 minutes on question 32.)

32 (a) A container ship is a cargo vessel which is designed to carry cargo in its holds and on deck, as illustrated in Fig. 32.1.

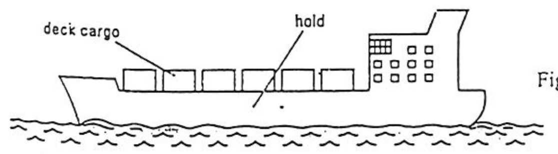
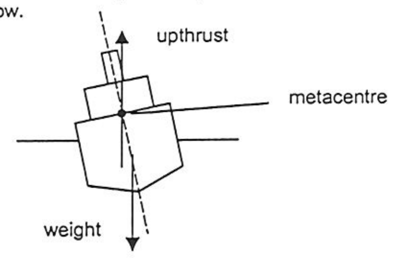


Fig. 32.1

(i) Explain how the stability of a ship is maintained. [4]

- Stability of the ship depends on the relative positions of the metacentre and the centre of mass.
- When the ship is floating in the water, it experiences an upthrust. The upthrust acts from the centre of geometry of the displaced water known as the centre of buoyancy. The vertical projection from this centre of buoyancy to the centre-line of the ship is the metacentre.
- When the metacentre is above the centre of gravity, then there will be restoring couple that tends to restore the ship to its equilibrium position. Hence , the ship is stable, as shown below.



Most students managed to obtain only 2 out of the 4 marks. Common omission was a well-labelled diagram which will help students explain what is meant by the metacentre and the restoring torque when metacentre is higher than the centre of gravity.
In fact, quite a few students did not state the condition for stability – "metacentre needs to be higher than the centre of gravity" in their answers.

(ii) Hence discuss the importance of the correct loading of the container ship with regard to light and to heavy containers. [2]

- As discussed in part (i), for the ship to be stable, the metacentre should be above the centre of gravity.
- This will mean that heavy containers should be loaded first (in the hold) and lighter ones later (on the deck) so that the centre of gravity can be as low as possible to make the ship stable.

Not many problems faced here by students though quite a large proportion did not use the terms "hold" and "deck" appropriately if at all. Some mentioned put the heavy containers first but did not explicitly state that they should be loaded into the lower part of the ship. A few thought that a container refers to the ship itself.

32 (b) Icebergs commonly found floating in the North Atlantic are 30 m high (above the water) and 400 m × 400 m across. The density of ice is 920 kgm^{-3} and the density of seawater can be taken as 1000 kgm^{-3}. What is the total volume of such an iceberg (including the volume below the water)? [3]

- Let V_{ice} and V_{wd} be the volumes of the entire iceberg and the water displaced and ρ_{ice} and ρ_{wd} be the densities of ice and water respectively.
- Since the iceberg is floating, weight of iceberg = weight of water displaced.
  $(V_{ice})(\rho_{ice})g = (V_{wd})(\rho_w)g$
  $(V_{ice})(0.92 \times 10^3) = [(V_{ice})-(30)(400)(400)](1.00 \times 10^3)$
  Hence, $V_{ice} = 6.0 \times 10^7\ m^3$

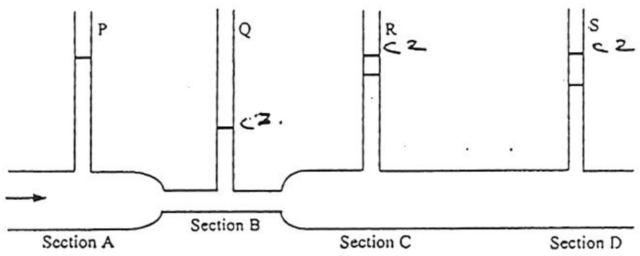
About half of the students managed to solve this problem. Many used volume of the ice that is above the sea as the volume of the water displaced which, of course, led to the wrong answer. Other common mistakes include omitting "g" when calculating weights.

(c) The diagram shows a Venturi Duct formed in a pipeline by replacing part of a horizontal tube of uniform cross-sectional area with a tube of smaller cross-sectional area.

1. An ideal liquid X of density 750 kgm^{-3} enters Section A at a speed of 0.67 ms^{-1}. The cross-sectional areas of Sections A and B are 0.040 m^2 and 0.010 m^2 respectively. The pressure at Section B is 0.60 × 10^5 Pa. Find the pressure at Section A. [2]
   Using the equation of continuity,
   $A_1v_1 = A_2v_2$
   $v_2 = (0.67)(4.0 \times 10^{-2}\ m^2)/(1.0 \times 10^{-2}\ m^2) = 2.68$
   $p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
   $p_1 - 0.6 \times 10^5 = (0.5)(7.5 \times 10^2)(0.67)^2(4^2-1)$
   $p_1 = 0.63 \times 10^5$ Pa

   Most managed to do this part. Common errors include omitting to take the square of the speeds and taking new speed as 1/4 of the original instead of 4 times.

2. Copy the above diagram *onto your answer script*, showing the possible liquid levels in each of the tubes P, Q, R and S, all of which are of the same size. [2]



3. Liquid X is replaced with an *incompressible* and *viscous* liquid Y. The direction of flow is unchanged. Show on the same diagram you have drawn for part (c)2. the possible liquid levels in each of the tubes R and S, assuming that the liquid level in P is the same as before. Label your answers clearly. (shown in red) [2]

2. A surprisingly large number of students thought that the liquid level for Q is higher than that of P – this is worrying – it probably meant that many students cannot appreciate the essence of Bernoulli equation.
3. Many thought that with a viscous liquid, the speed of flow will reduce and hence incorrectly conclude from Bernoulli equation that the liquid levels will be higher than before. In fact few appreciate the need of a pressure gradient to maintain the flow of a viscous liquid.

Section C **Answer only ONE question on writing paper.**
(You are advised to spend not more than 30 minutes on a question.)

33(a) Fig. 33.1 shows a cross-section through a compact disc.
The metal layer of a CD is the recording surface and contains narrow ridges, which form a spiral around the disc.

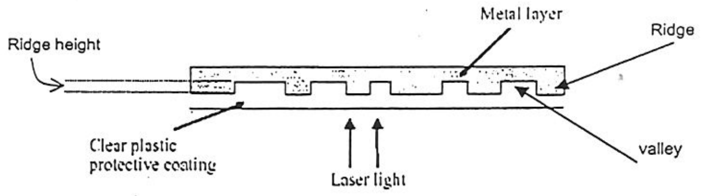


Fig. 33.1

Red ***monochromatic*** laser light of wavelength 780 nm is used to view these ridges. When the light meets a ridge some of it scatters in all directions and some ***interferes destructively*** with light reflected from neighbouring valleys.

(i) Explain the meaning of the words in *italics* in the passage above.

monochromatic : light of <u>single wavelength</u> or frequency
interferes destructively : waves <u>superimpose</u> on each other giving <u>zero resultant amplitude</u>.

> **Comments**
> Explanation was very satisfactory and most students did explain the two terms correctly. No mark was given to those that merely mentioned that waves are out of phase without stating <u>π radian</u> out of phase. Some students thought that when two waves meet, the crest of one wave must meet the trough of the other waves for destructive interference which is not true.

(ii) Calculate the frequency of the red laser light.
$f = c / \lambda = 3 \times 10^8 \ / 780 \times 10^{-9} = 3.85 \times 10^{14}$ Hz

(iii) If the speed of laser in the plastic coating is 1.94×10^8 ms^{-1}, show that the wavelength of the laser light in the plastic coating is approximately 500 nm.
$\lambda = v / f = 1.94 \times 10^8 \ / 3.85 \times 10^{14} = 5.04 \times 10^{-7} \cong 500$ nm

> **Comments**
> The calculations presented very few problems for (ii) and (iii).

(iv) The height of the ridges on a CD is approximately 125 nm. Explain how destructive interference occurs.
When the path difference between two interfering waves
= 2 x ridge height
= 2 x 125 nm
=250 nm
$\cong \lambda / 2$,
the waves are in anti-phase with each other and resultant amplitude will be zero.

> **Comments**
> Very few sensible explanations were given. Many students just calculated the ratio of 125 nm to the wavelength of laser light without further discussion. In fact some thought that a phase different of $\pi/2$ of waves that causes the destructive interference.

33(a) (v) The infrared laser standard was fixed in 1980 because of the reliability and availability of relatively inexpensive lasers, which emit at 780 nm. However, blue light lasers are now being developed. These emit a wavelength about half that of the red light lasers. Will it be possible to play existing CDs using blue light laser CD players? Explain your answer.

NO, path difference is now λ, so waves from ridge and valley are in phase when they superimpose. The pattern of ridges and valleys will not give an on/off signal.

> **Comments**
> This question had a good discrimination but too few students were able to draw the correct conclusion. Very students were able to see that the waves are in phase now as the path difference is λ.

(b) Fig. 33.2 shows a uniform wire which is held taut but unstretched between a fixed point and a smooth cylindrical peg of radius 1.0 cm. The force constant of the wire is 9.6×10^2 Nm^{-1}. The tension in the wire can be increased by rotating the peg about its fixed axis so that some wire is wound onto the peg.

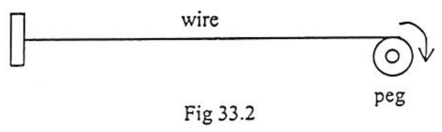


Fig 33.2

(i) 1 When the peg is rotated through an angle of 2π, calculate the tension in the wire.
$T = k x = (9.6 \times 10^2)(2\pi)(1.0 \times 10^{-2}) = 60.3$ N

> Be careful with radius and diameter.

2 Calculate the work done in rotating the peg through an angle of 2π. [4]
$W = ½ (9.6 \times 10^2)(2\pi)^2 (1.0 \times 10^{-2})^2 = 1.89$ J

> Cannot use ans in (b)(i)1 x displacement, because T is not constant.

(ii) The above wire is part of a musical instrument. Two knife-edges, A and B, are placed 0.36 m apart under the stretched wire as shown in Fig. 33.3. The mass of the wire between A and B is 6.4×10^{-4} kg. (Assume that the two knife-edges would not affect the tension in the wire.) The speed of the waves in the wire is given by $v = (T / m)^{1/2}$ where T is the tension and m is the *mass per unit length*.

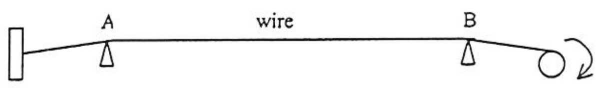


Fig 33.3

33(b)(ii) 1 Calculate the frequency of the fundamental note emitted when the wire between A and B is plucked. [3]

$v = (T / m)^{1/2} = [(30.2) / (6.4 \times 10^{-4} / 0.36)]^{1/2} = 130\ ms^{-1}$

$\lambda = 2 \times 0.36 = 0.72$ m

$f = v / \lambda = 130 / 0.72 = 181$ Hz

> T is the value from (b)(i)1 and m is mass per unit length not mass. For fundamental frequency, $\lambda = 2\,l$.

2 State THREE differences between the waves in the wire and the emitted fundamental note. [3]

	Waves in wire	Emitted waves
1.	Transverse waves	Longitudinal waves
2.	Stationary waves	Progressive waves
3.	Speed of transverse waves in wire = 130 ms^{-1}	Speed of sound = 330 ms^{-1}

> Need to recognise that waves in the wire are stationary waves while the emitted note is sound.

3 Fig 33.4 shows the shape of the vibrating wire at a certain instant. If the points on the wire are at maximum displacements at that instant, copy and sketch on the same diagram the shape of the wire after three-quarters of a period. [1]

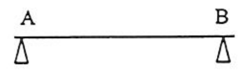
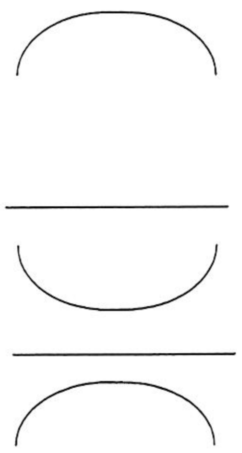


Fig. 33.4



t = 0
Starting shape as given by question

t = T/4

t = T/2

t = 3T/4

t = T

34(a) Distinguish between magnetic flux density B and magnetic flux Φ. [2]

Magnetic flux density is independent on the area of coil, while magnetic flux is dependent on the area of coil. [1] Magnetic flux density is a vector, whereas magnetic flux is a scalar. [1]

> 2 marks means 2 differences required. Definition is not good enough. Go for the most direct way to bring out the differences. Also, more specific answers like "area of coil" instead of just "area".

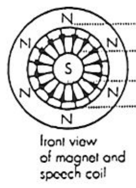


Fig. 34.2

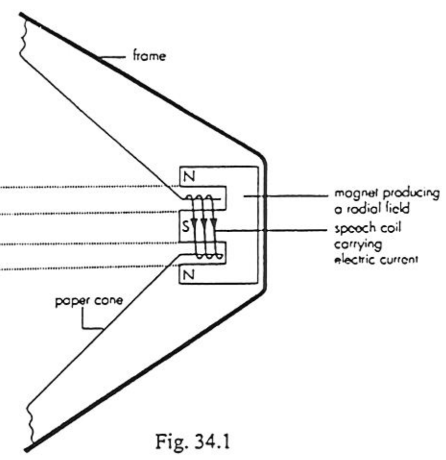


Fig. 34.1

(b) Fig. 34.1 above shows the side view diagram of a moving coil loudspeaker. Electrical current is passed through the coil of wire which is in the gap between the poles of a permanent magnet. The shape of the magnet is such that it provides a radial field as shown in Fig. 34.2 which is a front view diagram of the speaker. The coil is attached to the paper cone. Vibration of the paper cone gives rise to a sound wave.

(i) 1 The field is radial as shown in Fig. 34.2. Refer to Fig. 34.1, state the direction of movement of the coil when the current is flowing in the direction shown. [1]

Towards the right.

> Apply Fleming's left-hand rule on every point of the coil. Question specifies the use of Fig 34.1 for description.

2 Explain why the coil oscillates when an alternating current passes through the coil. [2]

The alternating current passing perpendicularly through the field at every point, changes direction periodically [1] leading to a magnetic force which is changing in direction [1].

> Must mention 3 things: current perpendicular to coil, current is changing direction periodically and coil experiences a periodic magnetic force.

34(b)(ii) 1 For a loudspeaker the magnetic flux density in the air gap is 0.70 T. The coil has 150 turns and a diameter of 20 mm. Show that the force on the coil when a steady current of 50 mA passes through it is 0.33 N. [2]

$F = NBIL\sin 90^\circ = 150 \times 0.7 \times 50 \times 10^{-3} \times 2\pi \times 20 \times 10^{-3}$ [2] $= 0.33$ N

sin 90° must be shown explicitly because it is part of the equation. N is the number of turns of the coil.

2 The coil, paper cone and suspension of this loudspeaker may be treated as a mass attached to a spring of force constant 3.6×10^6 Nm^{-1}. Calculate the displacement produced by the 0.33 N force. [2]

$x = F / k = 0.33 / 3.6 \times 10^6$ [1] $= 9.2 \times 10^{-8}$ m [1]

Some models of calculator need adjustment to setting to read to the value after rounding off to 2 sf.

(c) One rigid conducting loop of diameter 10.0 cm is suspended freely with non-conducting cords. A 0.50 T uniform magnetic field is directed parallel to the axes of the loops as shown in Fig. 34.3.

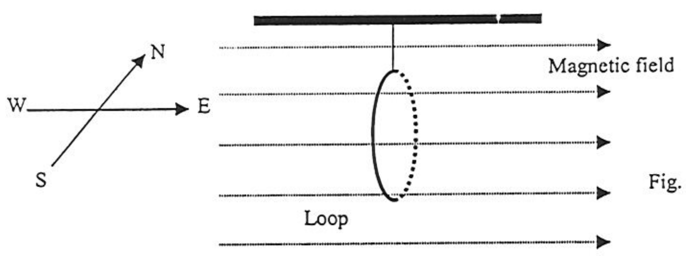


Fig. 34.3

(i) Determine the magnetic flux through the loop. [1]
Magnetic flux $= B A = 0.5 \times \pi \times (5/100)^2 = 3.93 \times 10^{-3}$ Wb

Comments
The calculations presented very few problems apart from a failure to find the radius.

(ii) The magnetic flux density falls to zero in a time of 0.010 s.
1. Using the law of electromagnetic induction, explain why a current flows in the loop. [1]

The decrease in magnetic flux density will lead to a change in flux through the loop. By Faraday's law, emf is induced in the loop due rate of change of flux linkage, which will cause a current to flow in a closed loop.

Comments
Very few students had a clear understanding of the laws of electromagnetic Induction. Most students thought that Lenz's law explains how induced current is produced without knowing that it helps to explain the direction of induced current only. There was confusion between flux cutting and flux linkage. Flux through the loop is changing but not flux cutting for this case.

34(c)(ii) 2. Copy the diagram of the loop and indicate the direction of the induced current in the loop. Justify your answer. [2]

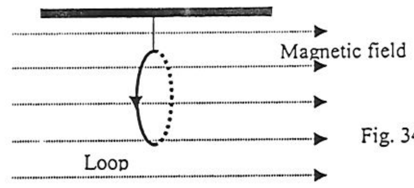


Fig. 34.3

The magnetic flux through the loop is decreasing, hence, by Lenz's law, the induced current will flow in the direction shown to produce a magnetic field in the easterly direction to oppose this decrease.

Comments
Most students were able to indicate the direction of the induced current correctly. However many were not able to use Lenz's law to justify the direction of the induced current. No mark was given to those who just merely state the law and did not use it to explain clearly.

3. Hence determine the average induced currents in the loop if the resistance is 0.10 Ω? [2]

$I = E / R = (BA - 0) / tR = 3.93 \times 10^{-3} / (0.010 \times 0.10)$ [1] $= 3.93$ A

Comments
Most scripts did show the correct answer.

(iii) State and explain what is likely to happen to the loop as the magnetic field reduces to zero. [2]
Forces acting on it are in a radial direction around due to induced current flows in the loop, leading to zero net force. Hence, loop will not move.

Comments
A surprisingly large number of students did not answer to the question correctly. They just mentioned that induced emf and current in the loop will reduce to zero. Loop experiencing forces was not mentioned at all.

(iv) The loop can be set to swing with two modes of vibration of large amplitude. One is in the NS direction and the other in EW direction. Assuming no air resistance, describe and explain separately the motion of the loop in these two modes of vibration. [3]

When loop is swinging in the N-S direction, there is no change of flux through the loop. No induced current flow in the loop. Hence, the loop will oscillate freely. When it is swinging in the E-W direction, there will be a change of flux and this change of flux will result in an induced current in the loop in a direction to oppose the change. Hence, the motion of the loop will be damped, and the coil will come to rest in a shorter time than when in free oscillation.

Comments
There were very few correct answers. Many thought that in the N-S direction, there is flux cutting, and hence current is induced and the motion is damped. In fact, there is no change in flux linkage. In the E-W direction, many thought that there is no change in flux linkage as the plane of oscillation is parallel to the magnetic fields; the loop will continue to oscillate which is incorrect.