Name : ________________________________ CT group : 15S________________

VICTORIA JUNIOR COLLEGE
2016 JC2 PRELIMINARY EXAMINATIONS

PHYSICS **8866/02**

Higher 1 **19 Sep 2016**

MONDAY

Paper 2 Structured Questions

2 pm – 4 pm

2 Hours

Candidates answer on the Question Paper

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group at the top of this page.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total (max. 80):	

This question set consists of a total of **19** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + (\frac{1}{2})at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = h\rho g$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$

Section A

Answer all questions in this section

1. A traffic policeman hiding behind a signboard detects a car speeding past him with a constant speed of 150 km h^{-1}. He starts his motorcycle 3.0 seconds later and gives chase, accelerating uniformly at 12 m s^{-2}. He overtakes the car at time t_1. The time when the car speeds past the policeman is taken to be t = 0.0 s.

(a) On the same axes, sketch a speed – time graph for the car and motorcycle. Indicate on the time axis, the moment when the motorcycle overtakes the car as t_1. [3]

(b) Hence or otherwise, calculate t_1. [3]

2. The simplified diagram in Fig 2 represents the trunk of a person bent forward, with the spine at an angle of 70.0° to the vertical. The extensor muscle, which joins the spine to the pelvis, makes an angle of 8.0° to the spinal column. The weight W of the person's trunk and head, which is 400 N, is shown to act at the point along the spine where the extensor muscle is attached.

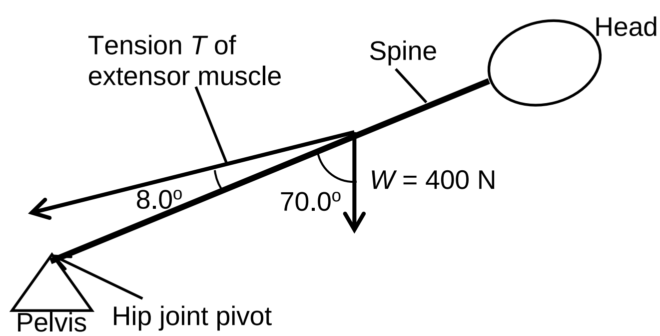

Fig 2

(a) Draw and label an arrow R on Fig 2 to show the direction of the reaction force acting on the spinal column at the hip joint pivot. [1]

(b) Explain why there would be no net moments acting on the body. [1]

(c) (i) Explain why the tension *T* of the extension muscle, the weight *W* and the reaction force *R* must form a closed triangle. [1]

(ii) Hence, or otherwise, calculate reaction force *R* at the hip joint and the tension *T* in the extensor muscle. [4]

3(a) Define magnetic flux density [1]

(b) A rectangular coil of N number of turns is lying with its plane at an angle to a horizontal uniform magnetic field B as shown in Fig 3.1. LM=KN=y and KL=MN=x. The coil carries a current of I. Fig 3.2 shows the view from the side KL.

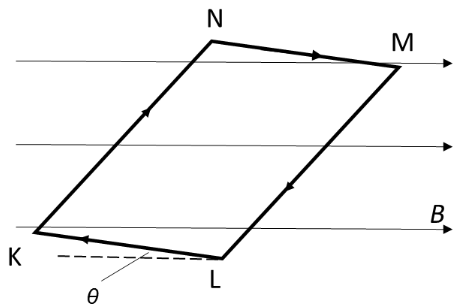

Fig 3.1

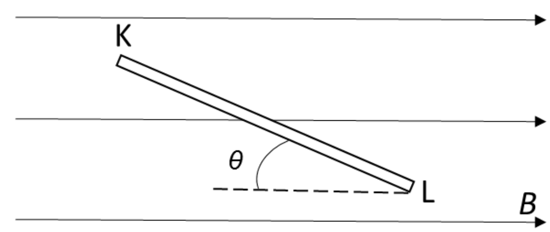

Fig 3.2

(i) Draw all the magnetic forces acting on the coil in Fig 3.1. [2]

(ii) Derive an expression for the torque τ acting on the coil in terms of x, y, N, I, B and θ. [2]

(c) A moving coil galvanometer, as shown in Fig 3.3 is constructed such that the plane of the coil (N turns, area A) remains parallel to the magnetic field B during rotation by using a radial field.

Fig 3.4 shows the schematic diagram of the galvanometer. A soft-iron core is fixed centrally between the semi-polar pole pieces of a permanent magnet. The coil is also held centrally between the pole pieces and it has a pointer attached. The coil moves in the space between the soft iron core and the magnet. A restraining torque provided by the spiral springs placed above and below the coil is used to measure the current *I* flowing through the coil.

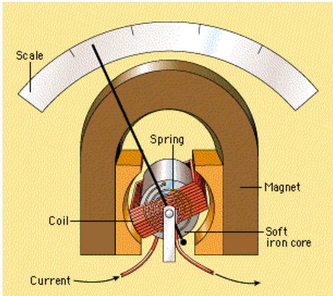

Fig 3.3

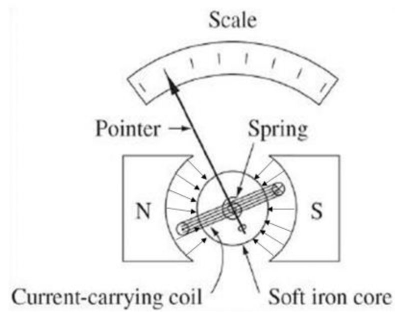

Fig 3.4

Torque provided by current in coil in radial field $\tau_{coil} = NBIA$, where $A = xy$,

Restraining torque supplied by spiral springs $\tau_{spring} = k\phi$,

where k is the spring constant and ϕ is the angle of deflection of the pointer from the zero point.

(i) Explain why when the pointer comes to rest, the deflection of the pointer ϕ is proportional to the current in the coil. [2]

(ii) Using the results of (b)(ii) and (c)(i), or otherwise, suggest why a radial field is used instead of a uniform field, in a galvanometer. [2]

4. Railway signals rely on a combination of resistors to trigger the correct colour of light. Figure 4.1 shows a simplified version of the circuit used. The relay can be considered to be equivalent to a resistor. When the potential difference across the relay is above 3.0 V it switches on the green signal. The signal is red when the relay potential difference is 3.0 V or less.

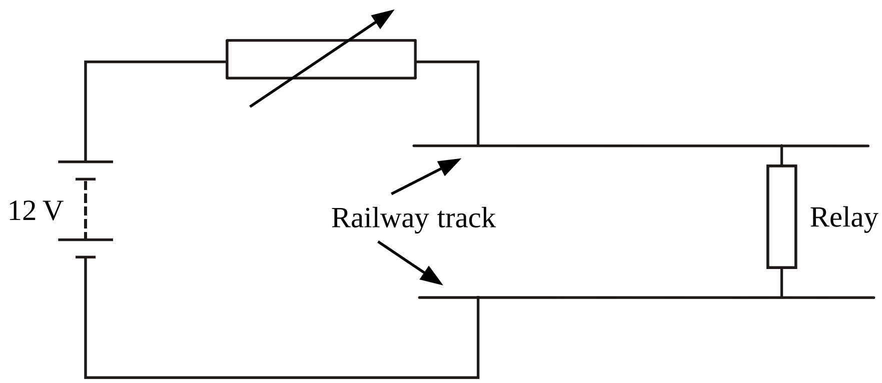

Fig. 4.1

(a) (i) The variable resistor is set to 10 Ω. The relay resistance is 5.0 Ω. Calculate the potential difference across the relay. Assume the railway track has negligible resistance. [2]

(ii) When the variable resistance is 10 Ω, the signal is green. Calculate the minimum increase in the variable resistance which will cause the signal to turn red. [2]

(b) The track is laid in sections of 100 m, with a length l between the rails. Each section of track is insulated from the next section. Ballast, usually made of broken up rock, is used to support the track as shown in Figure 4.2.

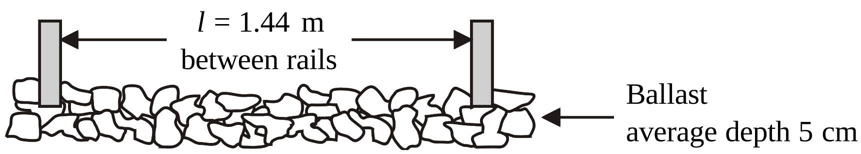

Fig. 4.2

(i) The ballast has a depth of 5.0 cm and a resistivity of 3.4×10^2 Ω m. Calculate the resistance of this 100 m section of ballast between the rails. [2]

(ii) The ballast resistance is in parallel with the relay. Calculate the combined resistance due to the above section of ballast and the 5.0 Ω relay. [2]

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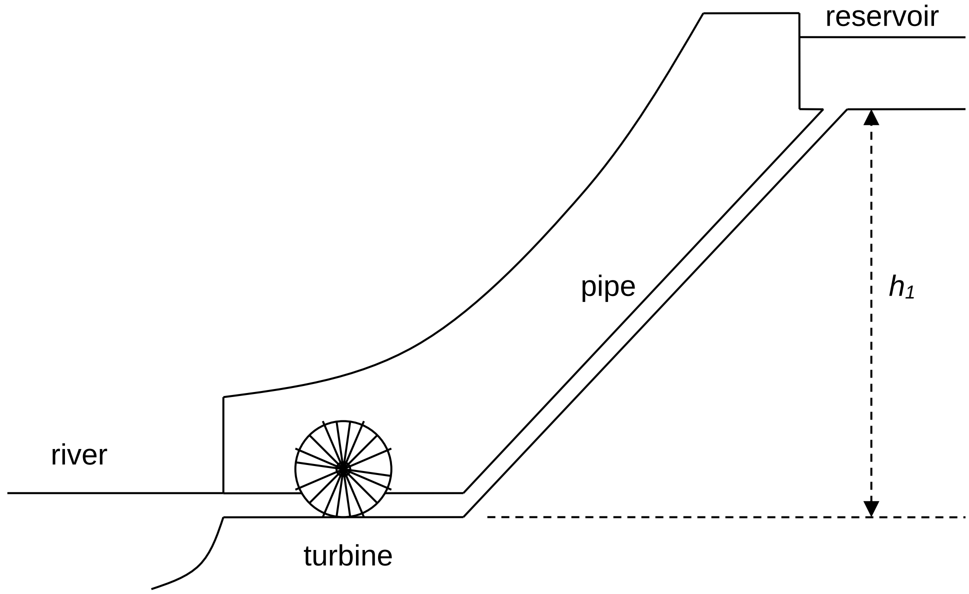


Fig. 5.1

Water from the reservoir falls through a pipe of height h_1 and then gives up all of its kinetic energy to a turbine which is connected to an electrical generator. The water is finally discharged into a river. Data for the power station are listed below.

height of pipe h_1	400 m
reservoir depth h_2	30 m
average area of reservoir	300 km^2
density of water	1000 kg m^{-3}
efficiency of power station	40 %
power supplied to consumer	500 MW

(a) Assuming that the depth of water in the reservoir is negligible compared to the height of the pipe, use the data above to calculate, for a fully filled reservoir,

(i) the mass of water available,

mass =…………………kg

[2]

(ii) the maximum kinetic energy transferred to the turbine,

kinetic energy = …………………J [2]

(b) Calculate the rate of transfer of kinetic energy to the turbine.

rate of transfer = …………………W [2]

(c) The reservoir is usually fully filled throughout the year. However, due to environmental changes, it suddenly stopped raining. Use your answers in (a) to calculate

(i) the duration, in days, the reservoir is able to supply power before it runs dry, assuming that the water flows at a constant rate.

duration = …………………days [3]

(ii) In reality, the duration will be much shorter. Suggest a reason for this.

………………………………………………………………………………

……………………………………………………………………………… [1]

Section B

Answer **two** questions from this section

6(a) State Newton's second law. [1]

(b)(i) Two small trays, each of mass 80.0 g, are connected by a light inextensible string which passes over a frictionless pulley, as shown in the Fig 6a below. The trays remain balanced.

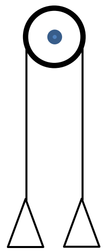


Fig 6a

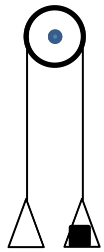


Fig 6b

A mass of 30.0 g is then placed on one of the trays as shown in Fig 6b.

Calculate

1. the acceleration of the trays, [1]

2. the tension in the string, [2]

3. the force exerted by the tray on the 30.0 g mass when in motion. [1]

(c)(i) A car of mass 900 kg travels up a slope inclined at 10^{o} to the horizontal with an acceleration of 0.60 m s^{-2}. At a particular speed the total resistive force (friction and drag force) is 500 N along the slope.

Calculate the driving force between the wheels and the ground at the instant when the car is moving with this speed. [2]

(ii) The maximum speed of the car up this slope is 20 m s^{-1}. When moving at this speed the total resistive force is 660 N.

1. Calculate the mechanical power produced at this speed. [2]

2. Explain the energy conversions that take place in this case. [2]

(d)(i) Explain, with appropriate example in each case, what is meant by

1. an elastic collision, [2]

2. an inelastic collision. [2]

(ii) A space rock of mass 20 kg travelling at a speed of 2000 m s^{-1} made a head on collision with an asteroid of 4000 kg travelling at 15 m s^{-1} in the opposite direction, and the space rock got embedded within the asteroid.

1. Calculate the velocity of the asteroid after impact. [3]

2. Explain qualitatively if the impact is an elastic or an inelastic collision. [2]

7(a) Explain what is meant by the [2]

(i) phase difference between two waves,

(ii) coherence of two waves.

(b) A sound system has two speakers S_1 and S_2 connected to the same source and placed at a distance of 1.2 m apart as shown in Fig 7.1. The speakers emit sound of frequency 2.8 kHz at a speed of 336 m s^{-1}.

A detector D is moved along the line XAY where A is equidistant from S_1 and S_2. The speaker S_1 emits a signal that arrives at point A with intensity *I*, and the speaker S_2 emits a signal that arrives at point A with intensity 3*I*.

Fig 7.1

(i) Determine the intensity of the sound detected at A in terms of *I*. [3]

(ii) B is at a distance 3.72 m from S_1 and 4.02 m from S_2. Explain whether the detector receives a maximum or a minimum signal at B. [2]

(iii) When the detector D is fixed at point B, a series of maximum and minimum values can be obtained by gradually increasing the frequency emitted by the speakers. Explain this phenomenon. [3]

(c) The variation of with distance x of the displacement y of a sound wave travelling from left to right at a particular instant is shown in Fig 7.2 below.

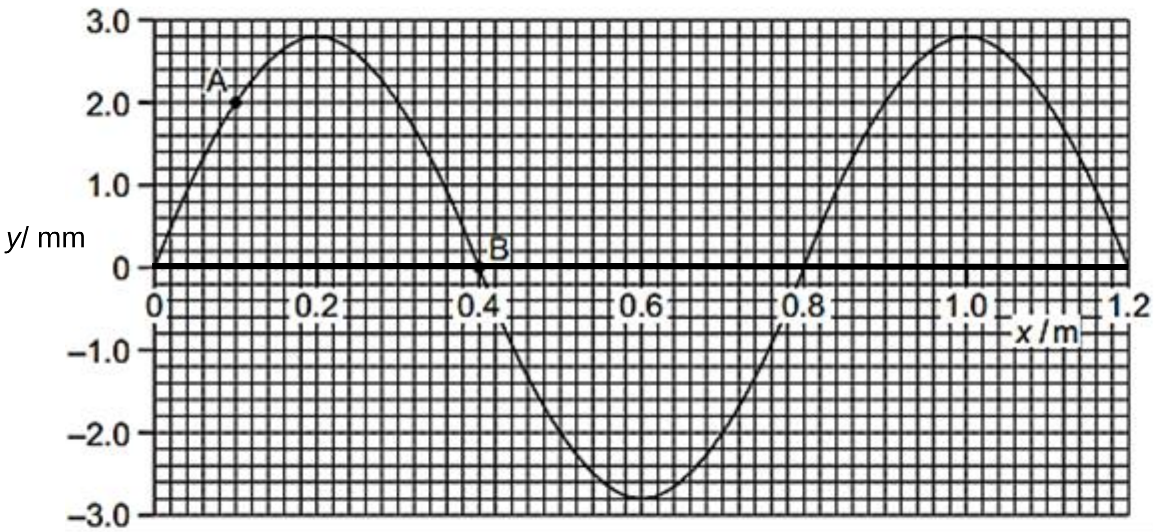


Fig 7.2

(i) Calculate the period of the wave if the speed is 300 m s^{-1} [2]

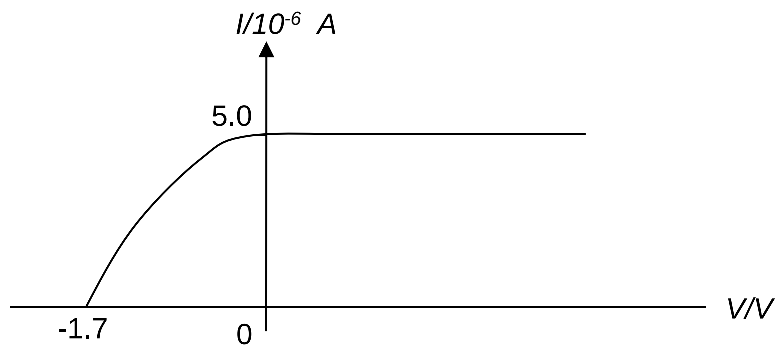
(ii) Hence, sketch a profile of the wave 0.53 ms later, showing the new position of point A, labelling it as A*. [2]

(iii) Calculate the phase difference between A and A*. [2]

\(d) A stationary wave is set up in a string in certain mode of vibration for which a point a quarter of its length from one end is a point of maximum vibration and the frequency is the lowest possible. The note has a frequency of 100 Hz.

Calculate the frequency emitted when it vibrates in the next mode such that this point is again a point of maximum vibration. [4]

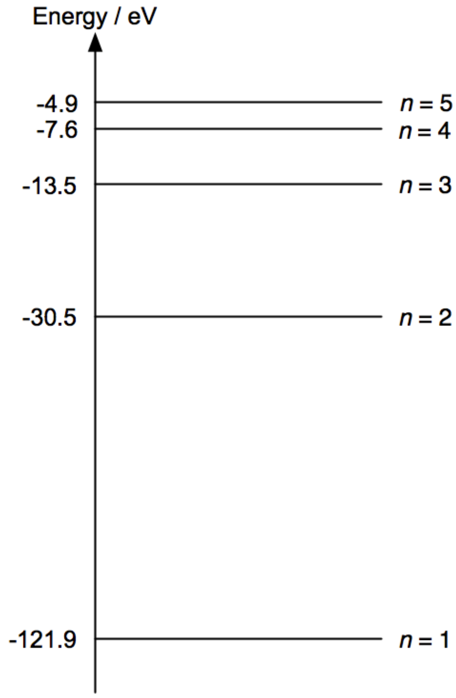
8(a) In a typical set-up for the photoelectric experiment, a metal surface is illuminated with radiation of wavelength 420 nm, causing the emission of photoelectrons, which are collected at an adjacent electrode. The graph below shows, for a given intensity, how the photoelectric current, *I* varies with the potential difference, *V* between the electrodes.



(i) Determine the threshold wavelength of this metal. [3]

(ii) Explain the significance of this threshold wavelength in relation to the nature of light. [2]

(b) The figure below shows a simplified representation of the 5 lowest energy levels of doubly ionised lithium (Li^{2+}) that has only one electron. Take the energy level of $n = \infty$ to be 0.0 eV.



(i) Explain how emission spectral lines provide the evidence for the existence of discrete energy levels in an atom. [2]

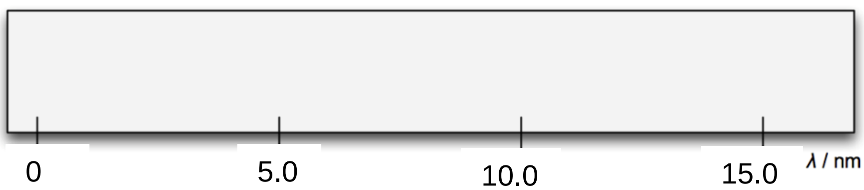
(ii) Explain why the ionised lithium vapour in a discharge lamp must be at low pressure in order to produce an emission spectrum. [1]

(c) Considering transitions between only these levels,

(i) calculate the wavelengths of the spectral transitions that produce the shortest and longest wavelengths. [3]

(ii) state the number of emission spectral lines that can be produced by transitions among these levels. [1]

(d) Sketch the emission spectrum of the lithium vapour corresponding to *only* those transitions that involve the $n = 1$ energy level. Use vertical lines to denote the relative positions of the spectral lines. [3]



(e) (i) 1. Explain what is meant by the term *ionisation energy.* [1]

2. State the value of the ionisation energy of the lithium ion. [1]

(ii) The work function of lithium metal is less than 3.0 eV. Suggest why the ionisation energies of an atom are always higher than the work function of the metal of the same element. [3]

End of Paper