L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2019 FIRST SESSION

SUBJECT:	**Physics**
DATE:	27th April 2019
TIME:	4:00 p.m. to 7:05 p.m.

A list of useful formulae and equations is provided. Take the acceleration due to gravity $g = 9.81\ ms^{-2}$ unless otherwise stated.

SECTION A
Attempt all 8 questions in this section. This section carries 50% of the total mark for this paper.

1. Two cables from a tower crane support a uniform concrete beam horizontally (see Figure 1). The distance between each end of the beam and the nearest cable connection is equal. Each cable is inclined at an angle of 35° to the vertical. The beam has a mass of 2650 kg. The tension in each cable is T.
   a. Draw a free body diagram showing the forces acting on the concrete beam. (2)
   b. State the value of the total vertical upward force acting on the concrete beam. (2)
   c. What is the resultant horizontal force acting on the concrete beam? (1)
   d. Find the value of T. (2)
   e. The points of attachment of the cables to the beam are now moved closer together. State, giving a reason, whether the tension in each cable becomes larger, stays the same or becomes less. (1)

   (Total: 8 marks)

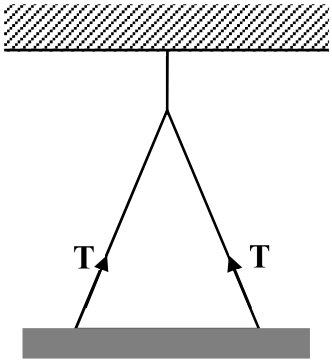

Figure 1

2. a. Two bodies P and Q collide. Before the collision, body P was moving on a horizontal plane, while body Q was at rest on the same plane. Ignoring friction and air-resistance, can both bodies P and Q remain at rest immediately after the collision? Explain your answer, making reference to a specific law of Physics which applies to this situation. (2)
   b. A delivery van of mass 1845 kg is travelling at 20 ms^{-1}. The driver applies the brakes for 1.8 s to come to a complete stop.
      i. Calculate the average force required to bring the van to rest. (2)
      ii. Explain how the average force to stop the van would change, if the van was carrying a heavier load and the brakes were applied for the same amount of time? (1)
   c. Explain why crumple zones make cars safer. (1)

   (Total: 6 marks)

3. a. A 40 W filament lamp is switched on and takes 6 s to light up brightly. Show how the First Law of Thermodynamics can be used to describe what is happening to the filament of the lamp during the first 3 s after switching on, assuming that the filament keeps the same temperature as that of the surroundings, during this time interval. (3)

b. A fixed amount of gas in a cylinder has a pressure of 2.0×10^5 Pa. The piston has an area 3.0×10^{-3} m^2 and is pulled out slowly a distance of 10 mm. If the cylinder is insulated, calculate the change in internal energy of the gas, stating the unit of your answer.

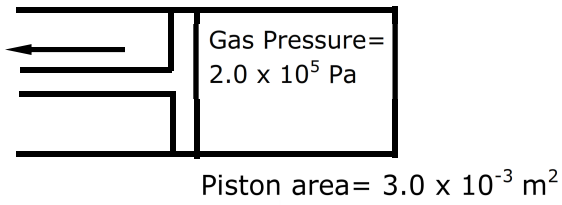

Figure 2

(2)

(Total: 5 marks)

4. a. In the equation $I = nAve$, I represents the current in Amperes due to the flow of charge carriers having a charge e, measured in Coulombs. The cross-sectional area of the material is represented by A, in m^2. What do the letters n and v represent? (2)

b. Why are insulators said to have negligible values for n? (2)

c. "In a series circuit, when current flows from a thick conductor to a thinner one made from the same material, the electrons slow down." Is this statement True or False? Explain your answer using the equation in part (a). (2)

(Total: 6 marks)

5. Point charges are placed at each corner of a rectangle, as shown in Figure 3. X is a point at the centre of the rectangular shape.

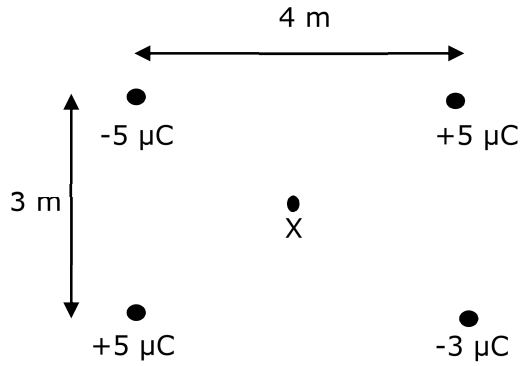

Figure 3

a. Calculate the electric field strength, E, at point X. (4)

b. A hollow metal spherical conductor, of radius R, is charged positively by induction.

i. Draw a diagram showing the distribution of charge over the sphere. (1)

ii. Sketch a graph to show how the electric field strength, E, varies with distance, r, starting from the centre of the sphere and reaching a distance 3R. (2)

(Total: 7 marks)

6. An electron, Z, is moving in the horizontal plane with a velocity, v, cutting magnetic field lines which lie in the same plane. The direction of the electron's velocity makes an angle of 42^{o} with the direction of the magnetic field (see Figure 4). The velocity of the electron is 3×10^{4} ms^{-1} and the magnetic field strength, B, is 5 T.

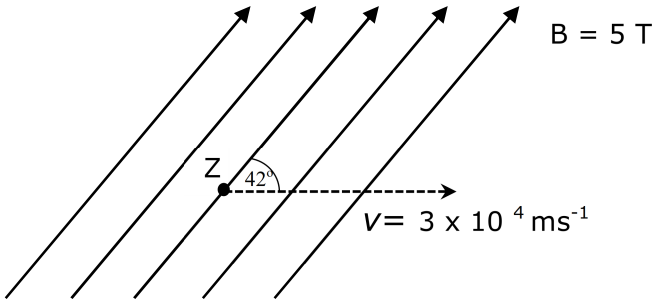

Figure 4

a. Determine the magnitude and direction of the force acting on electron Z. (3)
b. A similar electron Y, is at rest in the same region, in the same magnetic field. State the magnitude of the force experienced by Y. Explain your answer. (2)

(Total: 5 marks)

7. Paula is asked to experimentally determine the focal length of a converging lens. The apparatus provided, apart from the converging lens, consists of a ray box, a lens holder, a metre rule and a screen. Paula knows the lens equation: $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$.

a. With reference to the lens equation, explain what the letters v and u stand for. (2)
b. Carefully draw a ray diagram to show the formation of an image by the converging lens, when the object is placed at a distance equal to twice the focal length from the lens. (2)
c. Using the lens equation shown above, sketch a graph indicating what variables Paula should plot on the x and y axes, for the graph to be a straight line. Explain how Paula can use the graph to find the focal length. (3)

(Total: 7 marks)

8. Nuclear fusion and fission are reactions which release huge amounts of energy.
a. Give the meaning of fusion and fission. (2)
b. Mention an example that describes either the occurrence or the use of:
   i. nuclear fusion; (1)
   ii. nuclear fission. (1)
c. During a nuclear reaction, 380 atoms of Uranium-235 split, each releasing 2.7×10^{-8} J of energy. Determine the amount of mass which was converted into energy. (2)

(Total: 6 marks)

Please turn the page.

SECTION B

This question carries 14% of the total mark of this paper and must be attempted.

9. A number of different capacitors were connected, one at a time, in series with a milliammeter and an alternating current (a.c.) supply voltage. An appropriate voltmeter was connected in parallel across the capacitor in circuit (see Figure 5). The different currents resulting when using the different capacitors in the circuit were noted. The supply voltage, *V*, was kept constant at 15 V. The milliammeter and the voltmeter in use, read root-mean-square values of current and voltage respectively.

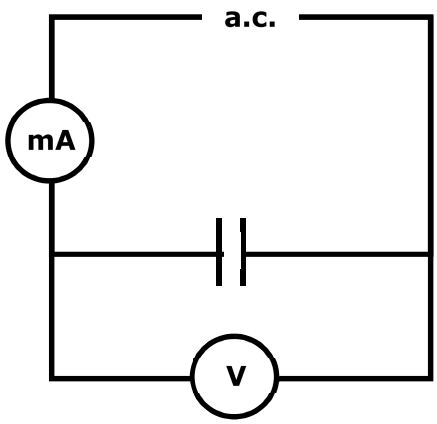

Figure 5

The relationship between the current, *I*, in the circuit and the capacitance, *C*, of a capacitor is:

$$I = 2\pi f V C$$

In the above equation, π is a constant equal to $\frac{22}{7}$, *f* is the frequency of the a.c. supply voltage and *V* is 15 V. A table of results was drawn up as follows:

Capacitance *C*/(μF)	Current *I*/(mA)	$2\pi VC/ \times 10^{-4}$ (V F)
2	10	
4	18	
6	29	
8	39	
10	50	

a. Copy the above table, filling in the missing values. (2)
b. Plot a graph of *I*/mA on the y-axis against ($2\pi VC$/(VF) x 10^{-4}) on the x-axis. (5)
c. Write the given equation in the form of y=mx + c, clearly indicating the gradient and the value of the y-intercept. (2)
d. Using the graph, determine the value of *f*, stating the unit. (3)
e. Mention a precaution that could be taken to make the result more valid. (2)

(Total: 14 marks)

SECTION C

Answer any TWO questions from this section. Each question carries 18 marks. This section carries 36% of the total mark for this paper.

10. a. During a laboratory session, a student is given the following circuit components:
A 3 Volt D.C. power supply, a variable resistor, a voltmeter, a milliammeter, connecting wires, a component marked X and a component marked Y.
The components X and Y are wrapped up in tape, and the student is asked to experimentally identify which of these is an ohmic device and which is a semiconducting device.

i. Explain the term ohmic. (2)

ii. Draw a circuit diagram to show how the student should connect the given components to carry out an experiment and come to a valid conclusion. (2)

iii. Give a brief explanation of an experimental procedure the student should adopt to be able to identify the devices. (2)

iv. Sketch **TWO** current/voltage characteristics that show the distinction between an ohmic and a semiconducting device. Label the axes and clearly distinguish between the graphs. (4)

b. The student is now given another circuit to work with. The new circuit has an LDR and a resistor connected in series. The potential difference across both components is 5 Volts (see Figure 6).

i. What is an LDR? (1)

ii. The resistance of the LDR is 1 MΩ at one instance, whilst the resistor has a fixed resistance of 10 kΩ. Calculate the potential difference across each circuit component. (3)

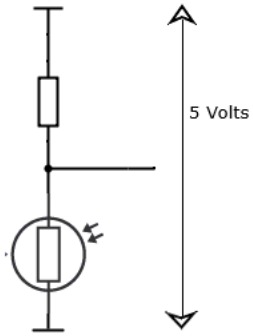

Figure 6

c. The student now connects another set of components to the circuit (see Figure 7). For the same values of resistance as described in part b (ii), determine the potential difference across the parts marked A and B. Comment on your answers giving reasons for your observations. (4)

(Total: 18 marks)

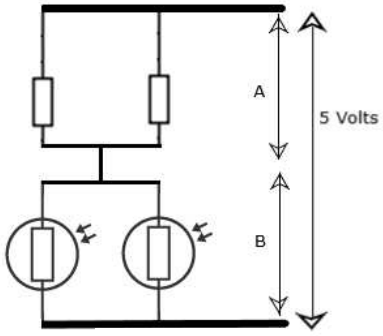

Figure 7

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11. a. Figure 8 shows the discrete energy levels of the Hydrogen atom. The transitions for some of the lines in the visible spectrum of atomic Hydrogen, called the Balmer series, are shown.

i. Calculate the energy, in electron Volts (eV), of the shortest transition in the Balmer series. (1)

ii. Convert the energy calculated in part (i) into Joules. (2)

iii. Calculate the frequency of the emitted radiation, as a result of this transition. (2)

iv. Calculate the wavelength of the emitted radiation. (2)

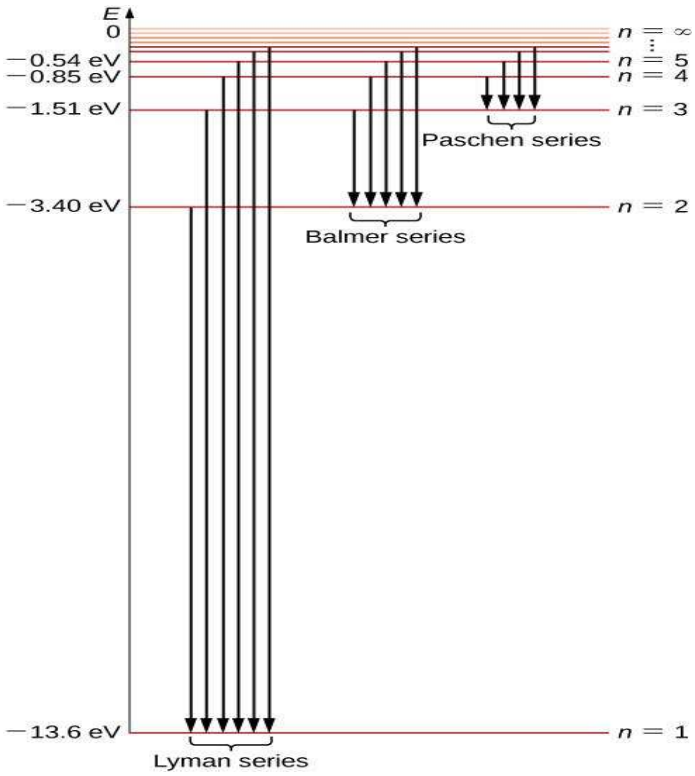


Figure 8

b. A Hydrogen atom in its ground state is irradiated with energy of wavelength 102.74 nm. The energy is absorbed by an electron.

i. What is meant by the ground state of an element? (2)

ii. Why are the energy levels shown labelled with negative energy values? (2)

iii. By considering the energy level values shown in Figure 8, determine the level that an electron in the Hydrogen atom can reach after absorbing the energy in question. Show **all** working in your answer. (3)

iv. If the electron now loses this previously gained energy, going back to the ground state, indicate **TWO** separate steps by means of which this could happen. Calculate the frequency of the radiation emitted in each step. (4)

(Total: 18 marks)

12. a. A laser produces a beam of red light of wavelength 633 nm. This is used as a light source in the double slit experiment. The distance between the double slits and the screen is 300 cm. The interference pattern obtained on the screen is such that the distance between one bright fringe and the 13^{th} consecutive bright fringe is 10 mm.

i. Calculate the fringe separation. (1)

ii. Determine the separation between the slits. (2)

iii. If the screen to slits distance is reduced, how would the fringe spacing be affected, if at all? (2)

iv. If the slits themselves were made narrower, but the slit separation is kept the same, how would the fringe pattern change? (2)

v. If green light was used instead of red light, in what ways will the fringe pattern change? (2)

b. Two sticks, labelled A and B, are being dipped in and out of the water in a ripple tank. A and B are moving in phase with one another. The sticks are a small distance apart (see Figure 9). The water waves produced are photographed and 10 complete waves are found to cover a distance of 26 cm. Moreover, it is observed that 48 waves pass a particular point in 20 seconds.

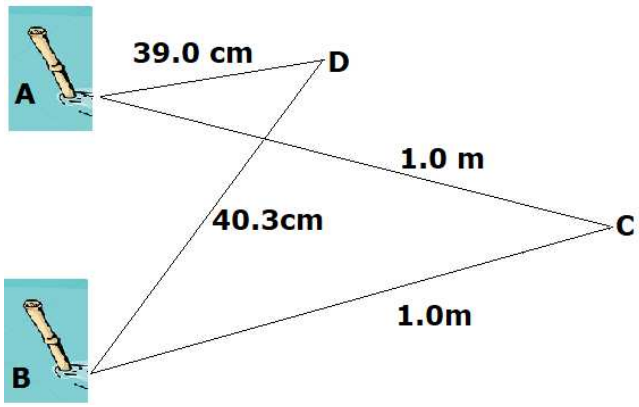


Figure 9

i. Using the data provided:
- calculate the wavelength; (1)
- determine the frequency; (2)
- calculate the velocity of the water wave. (2)

ii. A small piece of cork is placed at point C, which is 1 m away from both sticks. What would happen to it during the experiment? (2)

iii. The small piece of cork is now placed at point D, with AD=39.0 cm and BD=40.3 cm. How would the motion of the cork be described? Explain, showing how you arrived at this conclusion. (2)

(Total: 18 marks)

13. a. A student found a diagram on the Internet showing the design of a simple alternating current generator (see Figure 10). He decided to build an improved version of the generator to power up a light bulb connected to the terminals. He started by increasing the number of turns of the coil KLMN, from 1 to 200 turns. The student also connected the generator to his modified stationary bicycle, to help rotate the coil at 50 turns per minute. The coil dimensions were 10 cm by 15 cm and the magnets provided a flux density of 1 T.

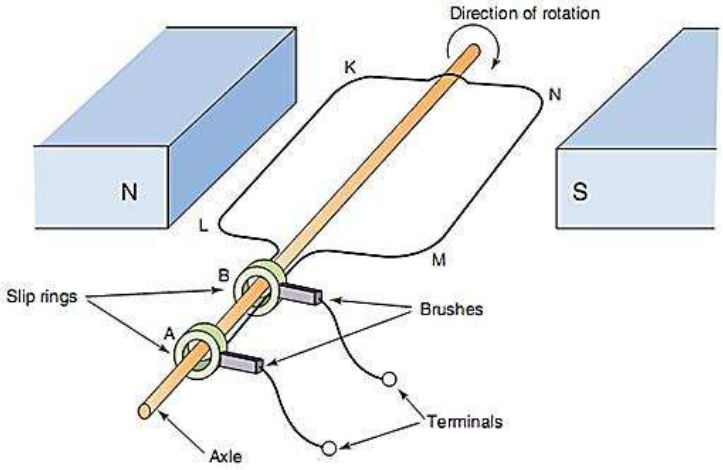
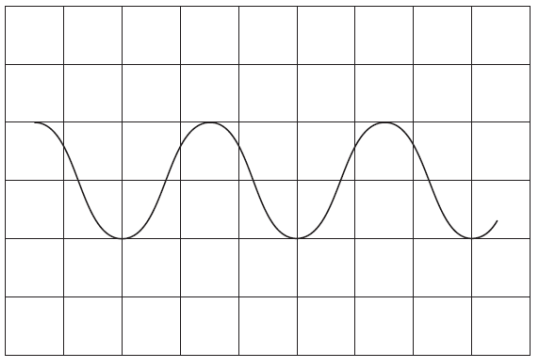


Figure 10

i. Calculate the periodic time of the coil when connected to the bicycle wheel. (1)
ii. Calculate the area of the coil. (1)
iii. Calculate the flux linking the 200 turns coil when the coil is in a vertical position? (3)
iv. With the position of NM as shown in the diagram, state in which direction the current flows in NM. Explain. (2)
v. State Faraday's Law of electromagnetic induction. (2)
vi. Propose **THREE** other improvements the student can make to this generator to produce a larger peak value for the potential difference. (3)

b. The student also started to familiarise himself with the use of the Cathode Ray Oscilloscope (CRO), obtaining the sinusoidal wave on the CRO screen (see Figure 11) when connecting the CRO to a power supply. Each grid division on the CRO screen measured 1 cm by 1 cm. The time base setting to produce this wave was 2 ms/cm. The Y-position knob was set at 0.5 Volt per division.

i. Calculate the periodic time of this voltage wave. (1)
ii. Determine the frequency of the supply voltage. (1)
iii. Copy the diagram in Figure 11 and add another voltage wave which has double the frequency. Label the wave with double frequency 2F. (2)
iv. On another copy of the original wave, draw another voltage wave showing how the original wave changes if the Y-position setting was changed to 1 Volt per division. Label the wave with the setting at 1 Volt per division 1V. (2)



Voltage wave on CRO screen
Figure 11

(Total: 18 marks)