L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2020 FIRST SESSION

SUBJECT:	**Physics**
DATE:	19th September 2020
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. a. Give **ONE** example of a derived quantity and express its units in terms of base units. (2)

   b. In the following equation, *s* represents displacement, *t* represents time and *P* and *Q* are two constants. Given that the equation is homogenous, find the units of P and Q.

$$s = Pt^2 - Qt^3 \quad (3)$$

   c. The equation $KE = mv^2$ is homogenously correct but physically incorrect. Explain. (2)

(Total: 7 marks)

2. Rachel is standing at point A on a merry-go-round as shown in Figure 1. The merry-go-round is moving with a constant speed in an anti-clockwise direction.

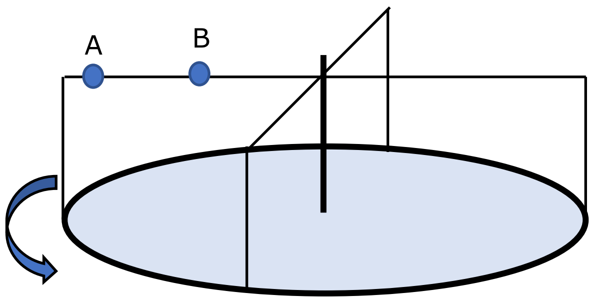

Figure 1

   a. State the name given to the force that keeps an object moving in a circle. (1)

   b. Explain why Rachel undergoes acceleration while rotating on the merry-go-round. (1)

   c. Rachel is standing at a distance of 1.2 m from the axis of rotation and her linear speed is 0.28 ms^{-1}.

      i. Calculate the number of complete rounds that Rachel rotates in 4 minutes assuming that her linear speed remains constant. (3)

      ii. Rachel moves to position B, halfway between A and the centre of the merry-go-round. Assuming her linear speed remains the same, what will now be the periodic time? (1)

(Total: 6 marks)

3. Last winter the mercury thermometer in the Physics lab measured a temperature of 14.2 °C.

a. Convert the temperature to Kelvin. (1)

b. Which thermometric property is being used to measure the temperature? (1)

c. State **ONE** quality that makes a mercury thermometer suitable for the measurement of temperature. (1)

d. When carrying out the experiment to find the specific heat capacity of a metal block, some drops of oil are added in the thermometer hole. Give **TWO** reasons for this. (2)

(Total: 5 marks)

4. a. Define tensile stress and tensile strain. (2)

b. A copper wire of diameter 0.18 mm and unstretched length of 2.2 m has one end suspended vertically from a fixed point while the other end supports a mass of 2.4 kg. The Young's Modulus of copper is 1.17×10^{11} Pa. Calculate:

i. the stress in the wire, correct to the nearest MPa; (2)

ii. the extension in the wire. (3)

(Total: 7 marks)

5. Two identical solid spheres, each of mass M, are placed equidistant from point X, which is a distance L_o away from the surface of each sphere as shown in Figure 2. The radius of each sphere is L_r.

Figure 2

a. Show that the gravitational force between the spheres is given by:

$$\frac{GM^2}{4(L_o+L_r)^2}$$ (2)

b. Given that L_o is 0.14 m, the diameter of **each** of the spheres is 0.012 m and the force between them is equal to 1.5×10^{-6} N, calculate:

i. the mass of **each** sphere; (3)

ii. the gravitational field strength at the surface of **each** of the spheres. (2)

(Total: 7 marks)

6. Figure 3 shows the displacement-time graphs of two identical particles X (solid line) and Y (dashed line) oscillating with simple harmonic motion.

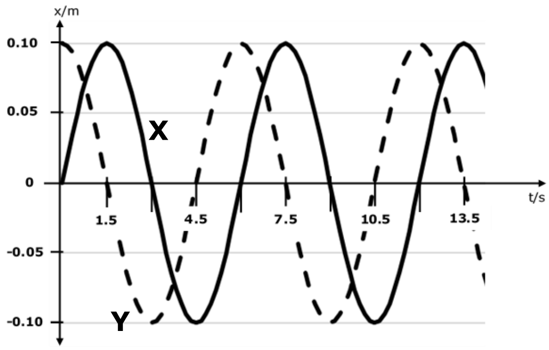

Figure 3

a. Using the graph, determine for particle X:

i. the amplitude of the oscillations; (1)

ii. the periodic time of the oscillations; (1)

iii. the frequency of the oscillations. (2)

b. Calculate the phase difference between the motion of particles X and Y and express it in terms of the periodic time. (1)

(Total: 5 marks)

7. Physicists attribute the formation of rainbows to total internal reflection and dispersion of light as it hits falling rain droplets.

a. Explain, with the aid of a diagram, why white light is dispersed when passing through a glass prism. (2)

b. State the **TWO** conditions required for total internal reflection to occur. (2)

c. A light ray travelling in water hits the water-air boundary at an angle of 52° with the vertical. Show that the ray gets totally internally reflected. ($n_{water} = 1.33$ and $n_{air} = 1.00$) (2)

(Total: 6 marks)

8. a. In the early 1900s, Ernest Rutherford designed an experiment to challenge Thomson's plum pudding model. In the experiment, positively charged alpha particles were fired at thin gold foil.
Write down **TWO** observations made in the experiment and their corresponding conclusions. (4)

b. An electron, initially in the fourth energy level (-0.85 eV) of a hydrogen atom, transitions to the second energy level (-3.40 eV), emitting energy at the same time.

i. In what form is the energy emitted in this process? (1)

ii. Calculate the frequency of the form of energy mentioned in part (b)(i)? (2)

(Total: 7 marks)

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

9. 400 g of an unknown liquid is held in a container surrounded by insulation. The container with the liquid is heated using an electrical heater. The temperature of the liquid and the quantity of heat supplied are observed and recorded every minute as shown in Table 1.

The relationship between the heat energy supplied and the change in temperature of the liquid is given by the equation $Q = mc\Delta\theta$ (assuming the transfer of energy to the walls of the container is negligible).

Table 1

Time (mins)	0	1	2	3	4	5	6	7	8
Heat Energy supplied (kJ)	0	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2
Temperature (°C)	25.0	29.5	34.0	39.0	44.0	48.5	54.0	59.0	63.5
Temperature rise (°C)									

a. Define the specific heat capacity of a liquid. (1)

b. Copy Table 1 and fill in the missing values. (2)

c. Plot a graph of the heat energy supplied (kJ) on the y-axis against the temperature rise (°C) on the x-axis. (4)

d. Calculate the gradient of the graph. (2)

e. Use the equation $Q = mc\Delta\theta$ to find a value for the specific heat capacity of the unknown liquid. Give the correct units for this value. (3)

f. The liquid was stirred during the experiment. Explain why this was done. (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. Describe an experiment to determine the acceleration of free fall *g*. The description should include:

i. a labelled diagram of the apparatus; (2)

ii. a description of the method used to carry out the experiment, including a list of the quantities to be recorded from the experiment; (2)

iii. **TWO** precautions that should be taken to obtain an accurate result; (2)

iv. the required graph and how the value of *g* can be obtained from the graph. (2)

b. A stationary ball of mass 0.04 kg lies at rest near the edge of a surface that is 2.5 m above the ground. It is hit horizontally with a wooden rod. The ball is in contact with the rod for 30 ms and leaves the rod with a horizontal speed of 27 ms^{-1}.

i. Calculate the change in the momentum of the ball. (1)

ii. Determine the magnitude of the average force which the rod exerts on the ball. (2)

iii. Assuming that the ball is projected horizontally from the edge of the surface at 27 ms^{-1}, calculate the time it takes the ball to reach the ground. (2)

iv. Determine the horizontal distance travelled by the ball before it hits the ground. (2)

v. Determine the magnitude and direction of the velocity with which the ball hits the ground. (3)

(Total: 18 marks)

11. a. Explain resistance of an electrical component. (2)

b. Figure 4 shows a circuit which was set up in the school laboratory. The battery has an internal resistance r.

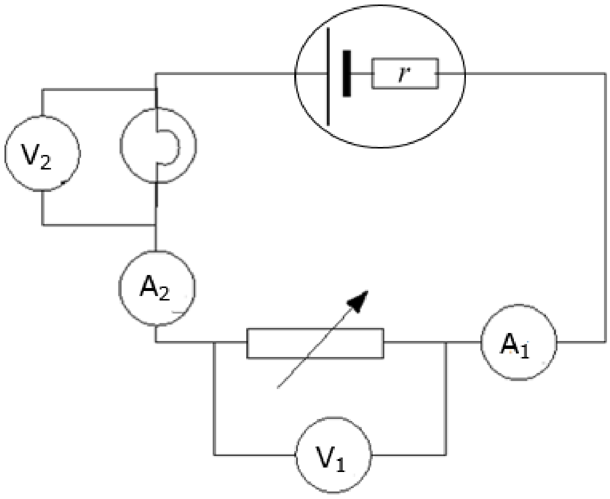

Figure 4

i. How will the readings of ammeters A_1 and A_2 compare to each other? Explain. (2)

ii. The resistance of the variable resistor is decreased. Assuming that the resistance of both the lamp and the variable resistor are in the same order of magnitude,

- how will the reading of current through A_1 change? Explain. (2)
- how is the potential difference read by voltmeter V_1 affected? State an assumption used to reach your conclusion. (2)

c. When the circuit is switched on, A_2 reads 0.3 A and V_2 reads 1.5 V.

i. What is the resistance of the lamp? (1)

ii. If V_1 reads 1.3 V and the e.m.f. of the battery is 3 V, calculate the potential difference across the internal resistance and the value of the internal resistance of the battery. (2)

iii. The circuit is switched on for 5 minutes. Calculate the energy dissipated by the bulb during this time. (2)

d. i. Explain Ohmic conductor. Sketch the I-V characteristic graph for such a conductor. (2)

ii. Sketch the I-V characteristic graph for a semiconductor diode. Explain the function of the diode. (3)

(Total: 18 marks)

12. a. The pressure exerted by the molecules of a gas inside a closed container, maintained at constant volume increases as the temperature increases. Explain why. (2)

b. State the first law of thermodynamics. Name each of the symbols used. (3)

c. The graph in Figure 5 shows how the pressure and volume of a fixed mass of an ideal gas change when it is first compressed isothermally from A to B and then allowed to expand adiabatically from B to C.

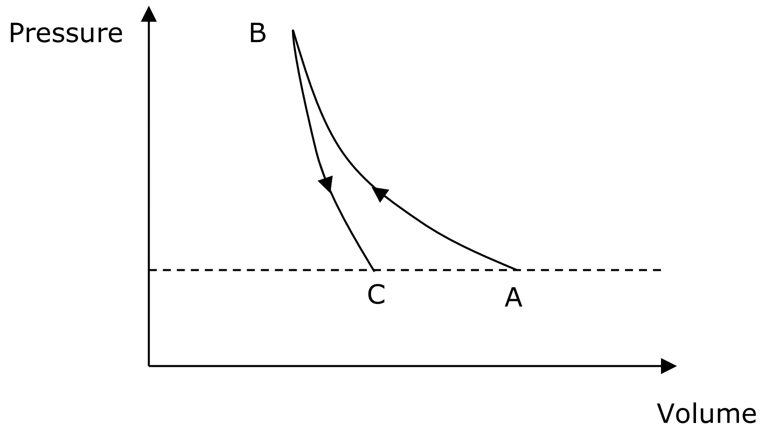

Figure 5

i. For **each** of the changes A to B and B to C shown on the graph, state whether:

- there is a change in the temperature of the gas; (2)
- there is heat transfer to or from the gas; (2)
- work is done on the gas or by the gas. (2)

ii. What does the area under a *p*-*V* graph represent? (2)

d. A gas is enclosed in a container, as shown in Figure 6, fitted with a tight piston of cross-sectional area 0.2 m^2. The pressure of the gas is maintained constant at 4000 Pa as the gas is heated. The piston rises by 0.15 m.

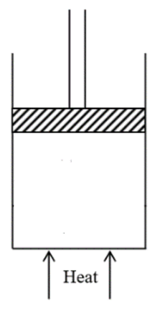

Figure 6

i. Calculate the work done on the gas. (2)

ii. If the internal energy of the gas increased by 8.0 J, calculate the amount of heat energy that was supplied to the gas during the process. (3)

(Total: 18 marks)

13. a. Define capacitance and time constant. (2)

b. List **THREE** factors that affect the capacitance of a parallel plate capacitor. (3)

c. Figure 7 shows a capacitor which was initially charged through a potential difference and is now discharging through a resistor.

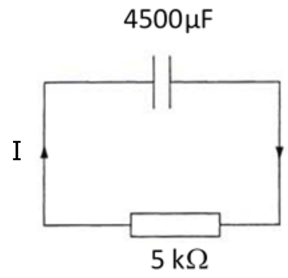

Figure 7

i. The energy, *E*, stored in a capacitor is given by the equation, $E = \frac{1}{2}CV^2$, where *C* represents the capacitance and *V* represents the potential difference. Calculate the initial energy stored in the capacitor when charged through a potential difference of 20 V. (2)

ii. Calculate the net charge on the capacitor. (2)

iii. Sketch a graph that shows how the potential difference across the capacitor changes with time as it is discharging. (1)

iv. The energy stored in the capacitor eventually decreases to zero. State where this energy is dissipated. (1)

v. Calculate the time constant of the circuit. (1)

vi. Calculate the current in the discharge circuit after the switch has been closed for a time equal to one time constant. (2)

vii. Give **ONE** practical use of a capacitor. (1)

d. A parallel plate capacitor of 700 pF capacitance, is made from metal sheets 0.3 mm apart and separated by a material of dielectric constant 1.5. Calculate the area of the metal plates. (3)

(Total: 18 marks)