L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2018 SECOND SESSION

SUBJECT:	**Physics**
DATE:	6th September 2018
TIME:	9:00 a.m. to 12:05 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 7 questions in this section. This section carries 50% of the total mark for this paper.

1. The electrostatic force, F, between two charges, Q_1 and Q_2 separated by a distance r is given by,

$$F = k\frac{Q_1 Q_2}{r^2}$$

where k is a constant of proportionality.

a. Determine the base units of charge. (3)
b. Given that the equation is homogenous, determine the base units of k. (4)

(Total: 7 marks)

2. A projectile is launched from a 340 m cliff with a horizontal speed of 7 m s^{-1}.

a. Determine the time of flight. (3)
b. Calculate the distance from the bottom of the cliff where the projectile lands. (2)

(Total: 5 marks)

3. a. State Newton's law of gravitation. (2)
b. The gravitational force between two objects A and B is 20 N. If the mass of B is twice as large as it is currently while the mass of A remains the same, how large is the gravitational force? (1)
c. Use Newton's law of gravitation to show that the speed of a satellite rotating in a circular orbit of radius R around the earth is given by,

$$v = \sqrt{\frac{G\ m_E}{R}}$$

where G is the universal constant of gravitation and m_E is the mass of the earth. (3)
d. Find the velocity of a satellite that has a mean height above the earth's surface of 2000 km. (2)
e. Explain the statement "The satellite is accelerating even though its speed is constant". (2)

(Total: 10 marks)

Please turn the page.

4. An experiment is carried out to measure the charge on a drop of detergent. Two parallel metal plates (shown in Figure 1), 6 mm apart are being used to determine the charge on a drop of liquid. The potential difference between the two plates is 420 V.
   a. Calculate the electric field strength between the plates. (2)
   b. Determine the magnitude of the electrical force on a small drop of liquid carrying a charge of 2.6×10^{-16} C when the drop is between the two metal plates. (2)
   c. How would the electrical force on the drop be affected if the distance between the two metal plates is increased? Explain. (3)

   (Total: 7 marks)

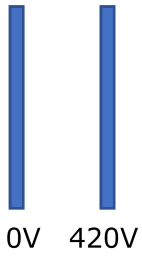

Figure 1

5. a. State the **TWO** laws of electromagnetic induction. (4)
   b. A magnet is allowed to fall through a coil. Using the laws stated in part (a), explain what happens to the size and direction of the induced current in the coil as the magnet is inside the coil, if:
      (i) the number of turns in the coil is increased; (2)
      (ii) the magnet is turned upside down. (2)

   (Total: 8 marks)

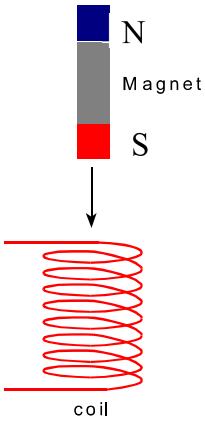

Figure 2

6. a. Show how an optical system is set up to produce a virtual image. (3)
   b. An old slide projector enlarges 3 cm high slides to a viewing height of 90 cm.
      (i) By what factor is the image magnified? (2)
      (ii) Is this image real or virtual? Explain. (2)

   (Total: 7 marks)

7. A granite column which forms part of a monument has a diameter of 0.25 m.
   a. Calculate the tensile stress on the column if it is supporting a load of 25 kN? (2)
   b. Under the load, the column is compressed by 0.1 mm. Calculate the compressive strain on the column, if its original length is 3.0 m. (2)
   c. Determine the Young modulus for granite. (2)

   (Total: 6 marks)

SECTION B

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

8. A student was provided with a simple pendulum suspended from a ceiling, a stopwatch and a meter rule to carry out an experiment to measure the height of the ceiling above floor level in a room. The equation relating the length of the simple pendulum l and its period T is given by,

$$T = 2\pi\,[l/g]^{1/2}$$

The student noted that the pendulum length *l* was equal to,

$$l = (H - h)$$

where H is the height of the ceiling and h is the height from the centre of the pendulum bob above the ground to the ground.

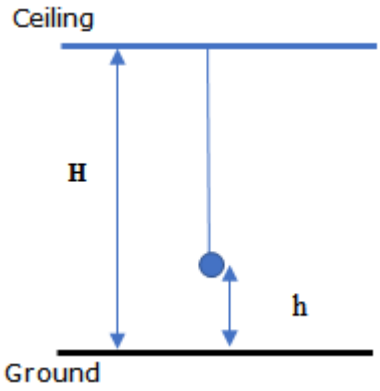

Figure 3

The student measured the height h in meters from the centre of the bob to the ground. Following this, the pendulum was set to oscillate through small angles and recorded the time taken to complete 50 oscillations. This was repeated for six times, each time varying h.

h / (m)	Time for 50 oscillations / (s)	Period T / (s)	T^2 / (s^2)
0.40	155.3		
0.60	148.8		
0.80	142.2		
1.00	134.0		
1.20	127.2		
1.40	119.2		
1.60	110.5		

a. Copy and complete the above table. (2)
b. Explain how you would use the tabulated data to plot a suitable graph in order to determine the height of the ceiling. (3)
c. Plot a graph of T^2 (s^2) against h (m). (4)
d. Use the graph to determine H. (4)
e. Why was the number of oscillations chosen to be large? (1)

(Total: 14 marks)

Please turn the page.

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.

9. a. During one oscillation, the simple pendulum shown in Figure 4, moves from position A to position B and back again to A. During this motion, the energy of the pendulum bob changes from one form to another. Assuming that the dotted line is ground level:

(i) state the energy interchange that the bob experiences as it moves from position A to position O to position B; (3)

(ii) state the types of energy that the bob has when it is midway between A and O; (2)

(iii) it was observed that after enough time, the pendulum stops swinging. Explain what happened to the initial energy of the bob. (2)

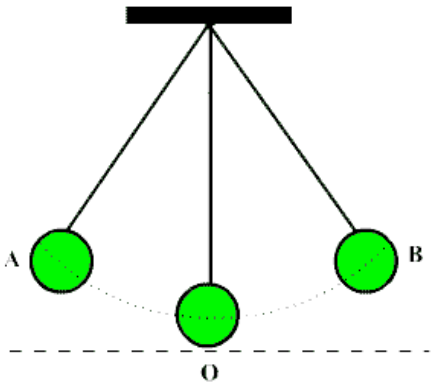

Figure 4

b. Figure 5 shows a section of a roller coaster in a vertical plane. A vehicle and its occupants, with a total mass of 920 kg, is released from point A. Ignoring frictional effects, calculate:

(i) the KE of the vehicle at point B; (2)

(ii) the velocity of the vehicle at point B; (2)

(iii) the PE of the vehicle at point C; (2)

(iv) the velocity of the vehicle at point C. (3)

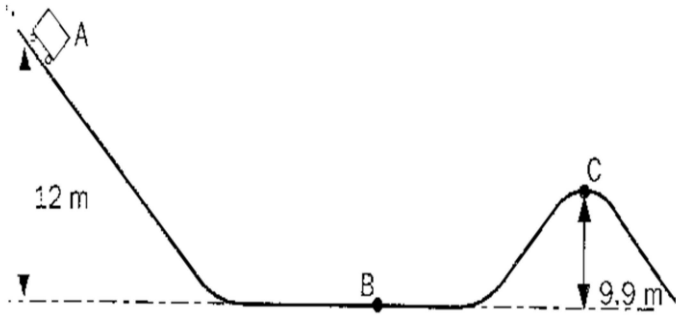

Figure 5

c. If the frictional effects were not negligible, state and explain how the velocity of the vehicle and its occupants at points B and C would be affected. (2)

(Total: 18 marks)

10. a. Write down the first law of thermodynamics, clearly explaining the symbols used. (3)
    b. What form does the above equation take when applied to an ideal gas that is being heated at constant volume? Explain. (2)
    c. A gas cylinder and piston are covered with heavy insulation. Re-write the first law of thermodynamics when the piston is pushed into the cylinder, compressing the gas. (2)
    d. Explain how the temperature of the gas in the cylinder changes when the gas undergoes the process described in part (c). (2)
    e. Figure 6 shows a gas undergoing a cycle of operations. Indicate, using the letters in the diagram, which of these processes is:

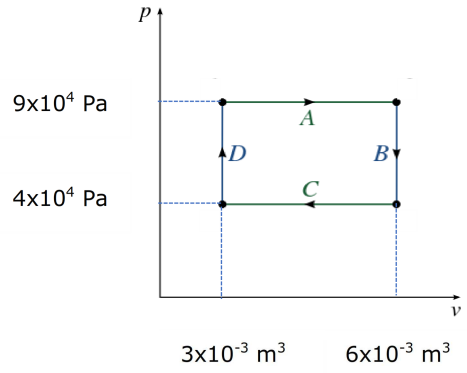

Figure 5

    (i) an isochoric process; (1)
    (ii) an isobaric expansion. (1)
    f. Explain why there is a positive net work done by the gas on its surroundings. (3)
    g. In process D, 250 J of heat are added to the system and in process A, 700 J of heat are added. Calculate the change in the internal energy for processes DA. (4)

(Total: 18 marks)

11. A conductor of length *l* and cross-sectional area *A* has an electric current *I* flowing through it. The conductor has *n* free electrons per unit volume. Each electron carries a charge *e*.
    a. Explain what is meant by the term free electron. (1)
    b. If the charges in the wire travel a distance *l* /m in time *t* / s, derive an expression for the current in terms of the drift velocity *v* of the free electrons, *n*, *A* and *e*. (5)
    c. A current of 2 A flows through a piece of copper wire of diameter 1 mm. Calculate the drift velocity of the free electrons if the number of free charge carriers per unit volume of copper is 10^{29}. (3)
    d. Use the derived equation in part (b) and the free electron theory to distinguish between conductors, semiconductors and insulators. (7)
    e. Explain why a wire heats up when a current flows through it. (2)

(Total: 18 marks)

Please turn the page.

12. a. Define magnetic flux density. (3)

b. Draw diagrams to show the magnetic flux pattern due to:

(i) a long solenoid, indicating clearly the magnetic poles created at each end of the solenoid and the direction of flow of the current in the solenoid; (4)

(ii) two long straight parallel wires carrying a current I, separated by a distance d and the direction of the current in one wire is in the opposite direction to that of the second wire. (3)

c. A straight wire of length 10 cm carrying a current of 2 A is placed at right angles to a magnetic field of magnetic flux density 0.2 T, as shown in Figure 7.

(i) Draw the resultant magnetic flux pattern when the wire is placed in the field of the magnet. (2)

(ii) Determine the magnitude of the force acting on the wire. (4)

(iii) What is the size of the force acting on the wire if it repositioned such that it is parallel to the magnetic field lines? Explain your answer. (2)

(Total: 18 marks)

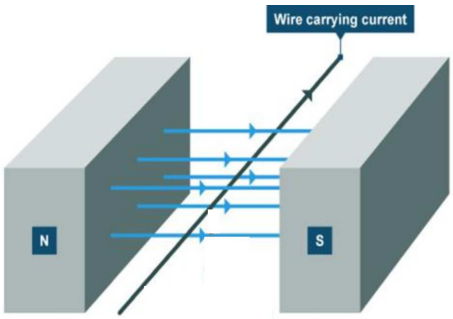

Figure 6