L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

**INTERMEDIATE MATRICULATION LEVEL**
**2018 FIRST SESSION**

| | |
|---|---|
| SUBJECT: | **Physics** |
| DATE: | 28th April 2018 |
| 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 $g = 9.81 \text{ m s}^{-2}$ 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. Peter was spraying his bicycle using a spraying can. Explain why the can gets cold after using it for some time. (2)

   b. A gas in a piston expands at constant pressure from a volume of $9.4\times10^{-4}$ m$^3$ to $1.13 \times 10^{-3}$ m$^3$. As the gas expands, it releases 620 J of heat and does 2880 J of work.
   i. Calculate the pressure at which this process occurs. (2)
   ii. Calculate the change in the internal energy of the gas. (2)

**(Total: 6 marks)**

2. a. With the aid of a labelled diagram, explain how a stationary wave on a string is formed. (3)

   b. State **TWO** differences between a stationary wave and a progressive wave. (2)

   c. State whether the following statements are True or False.
   i. Light waves are examples of stationary waves. (1)
   ii. Vibration of a guitar string represents a stationary wave. (1)

**(Total: 7 marks)**

3. A uniform electric field, E, of strength, $2.5 \times 10^4$ N C$^{-1}$ exists between two charged parallel plates. Each plate is 4 cm long. An electron with a speed of $2.9 \times 10^6$ m s$^{-1}$ enters the field in a direction that is perpendicular to the field lines as shown in Figure 1. By neglecting any effects due to gravity, calculate:

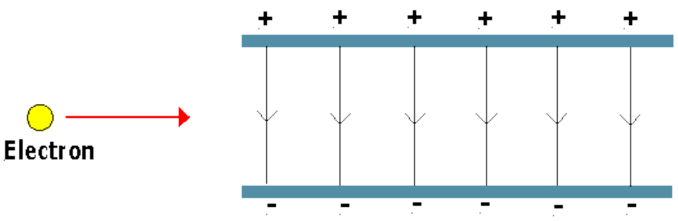


Figure 1

   a. the time taken for the electron to go through the plates; (3)

   b. the magnitude and direction of the force acting on the electron. (3)

**(Total: 6 marks)**

4. A capacitor C, of capacitance 27 pF, consists of a thin sheet of mica having a dielectric constant of 4.8, that is inserted between two aluminium sheets 0.35 mm apart.

   a. Calculate the area of each aluminium sheet. (2)

   b. State whether the capacitance of C would increase, decrease or remain the same, if:
      i. both the area of the thin sheet of mica and the plates is $2.2 \times 10^{-4}$ $m^2$; (1)
      ii. the mica sheet is removed and there is a vacuum between the aluminium sheets; (1)
      iii. the distance between the two aluminium sheets and thickness of mica sheet is reduced to 0.25mm. (1)

**(Total: 5 marks)**

5. A 12 cm long wire conductor is moved at a speed of 0.42 m $s^{-1}$ perpendicular in a uniform magnetic field of flux density $6.2 \times 10^{-3}$ T, as shown in Figure 2.

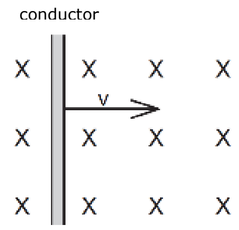

Figure 2

   a. Determine the rate of change of area covered by the conductor. (2)

   b. Calculate the induced e.m.f. across the ends of the conductor. (2)

   c. Explain what happens to the induced e.m.f. if the conductor is moved through the field (as shown in Figure 2) at a higher speed. (1)

   d. Describe what happens to the induced e.m.f. if the conductor is moved along the field lines. (1)

**(Total: 6 marks)**

6. Red light of wavelength $7.0 \times 10^{-7}$ m is shone at right angles through two slits 0.28 mm apart, as shown in Figure 3. Fringes are formed on a screen that is at a distance of 1.3 m from the slits.

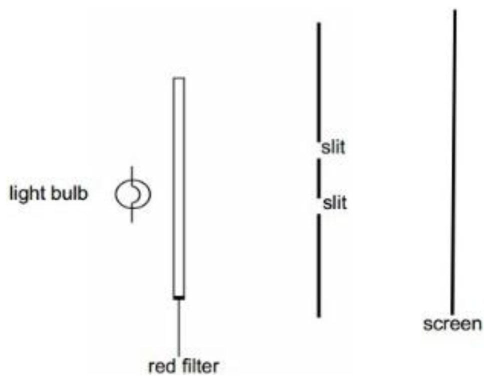

Figure 3

   a. Calculate the fringe spacing. (2)

   b. Describe the effect on the appearance of the fringes when:
      i. the screen is moved further away from the slits; (1)
      ii. red light is replaced with white light. (2)

   c. Briefly state **ONE** important conclusion on the characteristics of light that Thomas Young derived when he made use of a set-up similar to the one shown in Figure 3. (2)

**(Total: 7 marks)**

7. Figure 4 shows a ray of light undergoing total internal reflection.

   a. State **ONE** condition for total internal reflection to occur. (1)

   b. What are angles X and Y called? (2)

   c. Is angle X larger, smaller or equal to the critical angle of glass? Explain. (2)

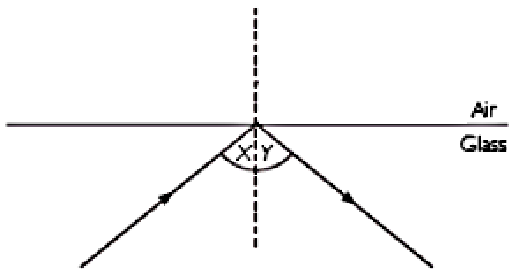

Figure 4

   d. State **ONE** practical application of total internal reflection. (1)

**(Total: 6 marks)**

8. The graph presented in Figure 5 illustrates how the activity in counts per minute of a radioactive isotope varies with time.

   a. Explain what is meant by the term half-life of a radioactive isotope. (2)

   b. Use the graph or otherwise to determine the half-life of the radioactive isotope. (1)

   c. Calculate its decay constant in days$^{-1}$. (2)

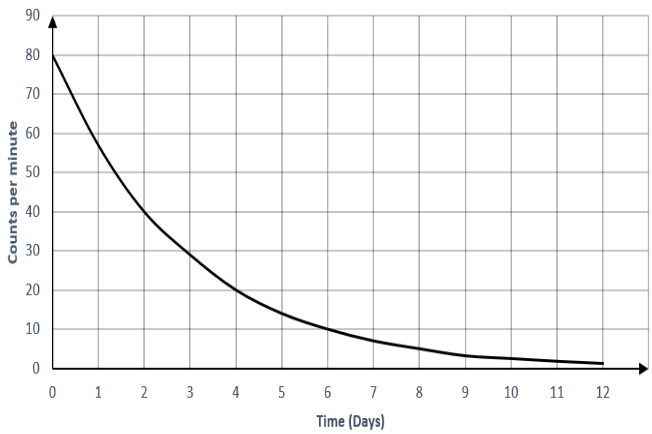

Figure 5

   d. Explain why in the absence of a radioactive source, a GM tube connected to a count rate meter would still record an activity which is not zero. (2)

**(Total: 7 marks)**

***Please turn the page.***

**SECTION B**

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

9. Figure 6 shows a battery of e.m.f. E and internal resistance r. It is connected in series to a switch S, an ammeter and a variable resistor R. A high resistance voltmeter is connected across the variable resistor R.

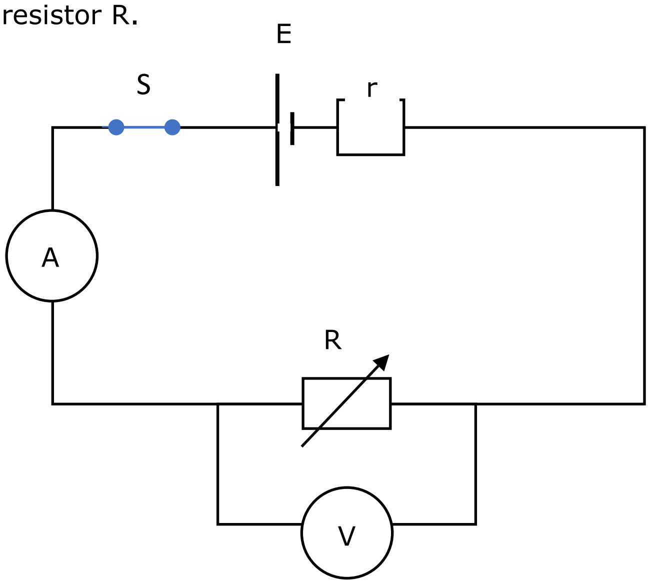


Figure 6

The equation that relates the e.m.f. E of the battery with the two resistors and the current is given by:

$$E = I(R + r) = IR + Ir \qquad \text{(i)}$$

This equation can also be written as:

$$E = V + Ir \qquad \text{(ii)}$$

where V is the potential difference across the variable resistor R and Ir is the potential difference across the internal resistor r. This experiment is aimed to determine a value for r and the e.m.f. E.

| Current I /mA | 45 | 105 | 170 | 210 | 250 | 300 | 350 | 400 |
|---|---|---|---|---|---|---|---|---|
| Current I /A | | | | | | | | |
| Voltage V /V | 2.98 | 2.90 | 2.87 | 2.81 | 2.74 | 2.72 | 2.64 | 2.58 |

a. Copy the table and fill in the missing values. (2)

b. Plot a graph of V / V on the y-axis against I / A on the x-axis. (5)

c. Write equation (ii) in the form y = mx + c, clearly indicating the parts of the equation representing the gradient and the y-intercept. (3)

d. Use the graph to determine a value for the internal resistance of the battery r and the e.m.f. E. (3)

e. List **ONE** precaution that should be taken during this experiment. (1)

**(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 spacecraft of total mass 1000 kg is travelling at constant speed around the Earth in an orbit of radius 12000 km, as shown in Figure 7. The gravitational field strength at that distance from the Earth's centre is 3 N/kg.

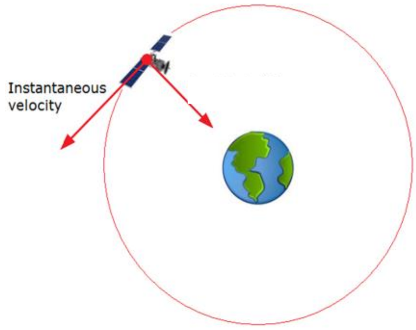


Figure 7

a. Explain, using a diagram, what is meant by a gravitational field and define gravitational field strength. (4)

b. Does the spacecraft need to produce a force from its rockets to keep moving at a constant speed? Explain. (2)

c. Determine the size of the gravitational force acting on the spacecraft. (3)

d. Calculate the speed of the spacecraft in its orbit. (3)

e. Calculate the time required by the spacecraft to orbit the Earth once. (2)

f. If the spacecraft had been in a circular orbit around the Moon instead of the Earth, it would experience a different gravitational force at this radius of orbit. Explain. (2)

g. When a spacecraft is no longer needed, it is given a thrust such that it re-enter the Earth's atmosphere. On re-entering the Earth's atmosphere, another force starts acting on it. State the name of the force and explain the effect that this force has on the motion of the spacecraft. (2)

**(Total: 18 marks)**

***Please turn the page.***

11. a. When an object undergoes circular motion, it does so by moving with a constant linear speed but with a changing velocity. Explain. (2)

b. A safe of mass 375 kg is being pushed up an inclined ramp with a force P to be securely installed inside a wall of a jewellery shop, as in Figure 8. The force of friction F acting between the safe and the ramp is 1492 N.

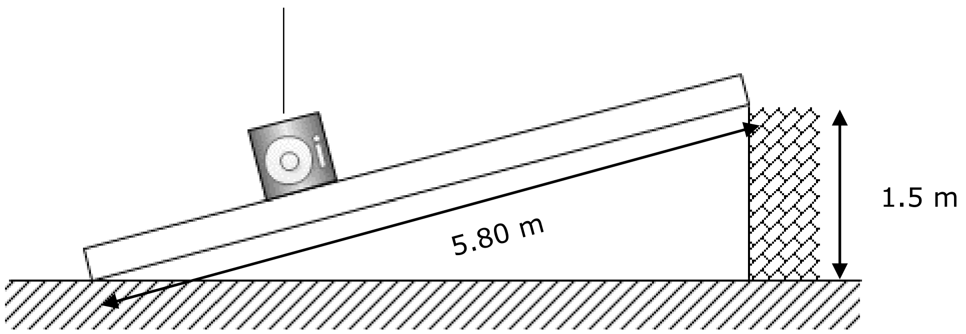


Figure 8

i. Copy the diagram and draw the forces acting on the safe. (4)

ii. Determine the magnitude of the pushing force P that is needed so that the safe just starts to slide upwards. (3)

iii. Calculate the normal reaction of the ramp on the safe. (2)

c. The equation for the gravitational attraction between two masses $M_1$ and $M_2$, a distance R apart is

$$F = \frac{GM_1M_2}{R^2}$$

i. What are the base units of the universal gravitational constant, G. (2)

ii. Kepler discovered that the orbital period T of the planet of mass M around the Sun are related to their distances R from the Sun by the following relationship,

$$T^2 = \frac{4\pi^2R^3}{GM}$$

Show that this equation is homogenously correct in terms of base units. (3)

iii. Although the above equation is homogenously correct in terms of base units, one still needs to verify its correctness through observation and data analysis. Explain this statement by using the above equation as an example. (2)

**(Total: 18 marks)**

12. a. In an experiment to measure the Young's modulus of a metal wire, two identical wires are suspended vertically side by side from the same rigid support. Loads are added to one of the two wires.
   i. Explain why the wires are chosen to be long and thin. (1)
   ii. Explain why the second wire is suspended alongside the first wire. (2)

   b. Sketch a Force-extension graph for a ductile material. Mark on the graph and explain the following:
   i. elastic limit;
   ii. yield point;
   iii. breaking point. (7)

   c. A bungee jumper of mass 60 kg jumps from a bridge, as shown in Figure 9. The unstretched length of the rope is 40 m. She jumps from a height of 100 m and falls a total of 70 m before she is brought to rest for the first time. Describe the energy changes that take place during these three stages of the first fall:
   i. as she starts falling downwards; (1)
   ii. as the rope becomes taut and starts extending; (3)
   iii. when she stops falling for the first time. (2)

   Ignoring air resistance, state the forces acting on the bungee jumper and the type of motion she experiences during:
   iv. the first 40 m of the fall; (1)
   v. the subsequent 30 m of the fall. (1)

Figure 9
*https://bit.ly/2JQdomB*

**(Total: 18 marks)**

***Please turn the page.***

13. a. Figure 10 shows the forces acting on a bus. Apply Newton's laws of motion to compare the magnitude of the forces acting on the bus for the following two cases:
   i. when the bus is stationary; (2)
   ii. when the bus is moving with a constant velocity. (2)

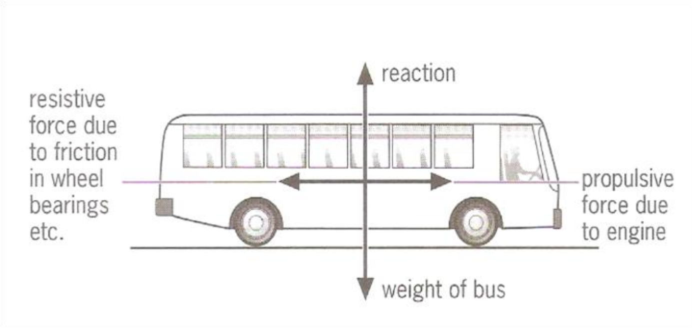

Figure 10

b. Describe the motion of the bus if:
   i. the propulsive force is larger than the resistive force; (2)
   ii. the bus encounters a patch of oil on the ground whilst moving at a constant velocity. (2)

c. The bus that was moving along a level road with constant speed now moves up an incline. Explain how it is possible for the bus to keep moving with constant speed. (2)

d. During a test drive, a dummy in a car is used to demonstrate the effects of a collision, as shown in Figure 11. During the collision the head of the dummy strikes the dashboard at 20 m/s and comes to rest in 0.02 s. The mass of the head is 5 kg.

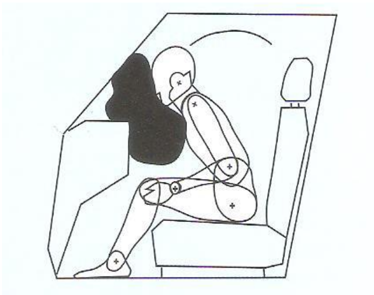
Figure 11

   i. Calculate the average force exerted by the dashboard on the head of the dummy during the collision. (3)
   ii. The test on the car is repeated with an airbag which inflates during the collision. During the collision the head of the dummy again travels forward at 20 m/s and is brought to rest by the air bag in a longer time interval. Explain why there is less risk of damage to the head of the dummy when the airbag is used. (3)

e. The front end of modern cars is designed to crumple on impact. Explain why this is done. (2)

**(Total: 18 marks)**