MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

UNIVERSITY OF MALTA, MSIDA

MATRICULATION EXAMINATION
INTERMEDIATE LEVEL
SEPTEMBER 2017

SUBJECT:	PHYSICS
DATE:	31st August 2017
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 $g = 9.81\ m\ s^{-2}$ unless otherwise stated.

SECTION A

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

Question 1

A student is measuring the periodic time for a compound pendulum as the length of pendulum is varied. The periodic time T of the pendulum varies with h (the distance between the point of suspension and the centre of gravity of the pendulum) according to the following equation, where g is the acceleration due to gravity:

$$T = 2\pi\sqrt{\frac{h^2 + k^2}{hg}}$$

a. What are the units of k for the equation to be homogeneous? (2)

b. Show that the unit of the term $\sqrt{\frac{h^2}{hg}}$ is the second. (3)

(Total: 5 marks)

Question 2

A force F acts on a body which is initially at rest. The force is always in the same direction but varies in size as shown in the graph of Figure 1.

a. Calculate the change in momentum of the body after 100 ms have elapsed. (2)

b. If the body has a constant mass, sketch a graph corresponding to the one shown in Figure 1, showing the variation of velocity with time over the 200 ms period. Briefly explain your answer. (3)

(Total: 5 marks)

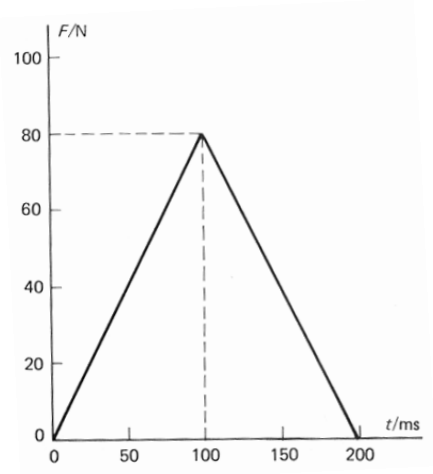


Figure 1

Question 3

A truck of mass 3.5 x 10 ^{4} kg attains a steady speed v while climbing an incline of 1 in 10, as shown in Figure 2.

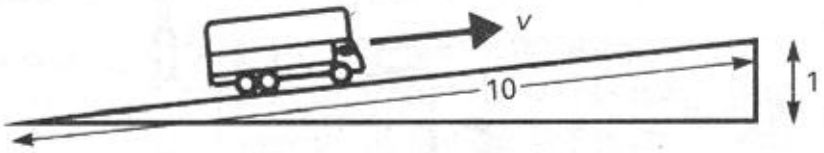


Figure 2

a. Find the angle which the incline makes with the horizontal. (1)

b. In terms of the forces acting on the truck, explain what it means when the truck moves with a steady speed. (Assume there is no friction.) (2)

c. Calculate the force exerted by the engine for the truck to continue up the incline with uniform speed. Carefully explain all working. (2)

(Total: 5 marks)

Question 4

Wires A and B are made of the same conducting material. Wire A has double the length and double the radius of wire B. The two wires carry the same electric current. Electric current is looked at as the flow of a number of charge carriers (electrons) moving with a drift velocity in a conductor.

a. Explain how a drift velocity usually results in a conductor. (1)

b. Find the ratio of the electron drift velocities in the two wires. (3)

c. Explain whether the drift velocity depends on the length of the conductor. (1)

(Total: 5 marks)

Question 5

A resistance network has been formed using the resistances shown in Figure 3.

a. Show that the effective/total resistance connected across the points X and Y is $\frac{8}{7}\,\Omega$. (3)

b. A 12 V battery is connected to the resistance network at X and Y. The battery has an internal resistance of 0.4 Ω. Calculate the current through the battery. (2)

(Total: 5 marks)

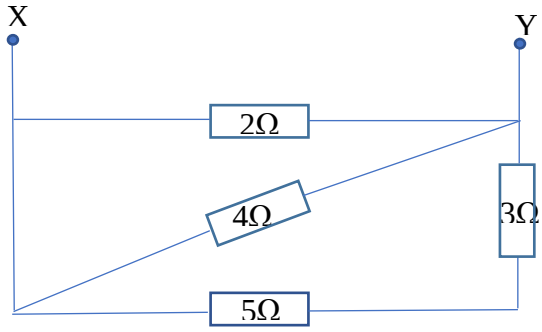


Figure 3

Question 6

a. Define gravitational field strength. (1)

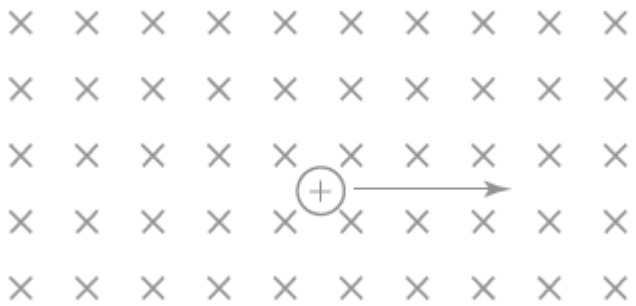
b. Draw a diagram to show the gravitational field of the Earth. (2)

c. As the distance away from the Earth increases, does the Earth's field remain constant, increase or decrease? Explain your answer. (2)

d. A satellite is in orbit close to the Earth. Given that the acceleration of free fall is 9.81 ms $^{-2}$ and that the radius of the Earth is 6.4 x 10 ^{3} km, calculate:
   i. the speed of the satellite; (3)
   ii. the period of the orbit. (3)

(Total: 11 marks)

Question 7



B = 0.2 T

Figure 4

A positive charge of 3.2 x 10^{-19} C and moving with a velocity of 2 x 10 ^{6} ms $^{-1}$, enters a magnetic field of flux density 0.2 T, acting perpendicularly into the paper. A force acts on the charge. (see Figure 4)

a. On a copy of the diagram, show the direction in which this force acts. (2)

b. According to Newton's second law of motion, a net force acting on the charge will give it an acceleration. How does this acceleration affect the velocity of the charge in magnitude and direction, while the charge moves through the magnetic field? (2)

c. Calculate the force acting on the positive charge. (2)

(Total: 6 marks)

Please turn the page.

Question 8

a. On a copy of the diagram in Figure 5, assuming total internal reflection takes place inside the prism, draw the path taken by the light ray. (3)

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

c. Draw a diagram showing a ray of light entering a 60° (equilateral) glass prism at an angle of incidence equal to 40°. Assuming it is sunlight which is now falling on a prism face, show the behaviour of white light as it passes through the glass prism. (3)

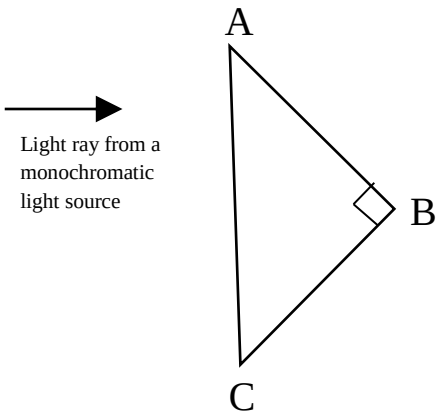


Figure 5

(Total: 8 marks)

SECTION B

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

Question 9

A student is performing an experiment to determine the acceleration due to gravity. He compresses a small ball against a spring and releases it such that it travels to the edge of the bench where it is projected horizontally onto the ground. This experiment assumes that the bench has a frictionless surface. The student records the compression distance x and the distance s_x between the foot of the bench and the point where the ball hits the ground.

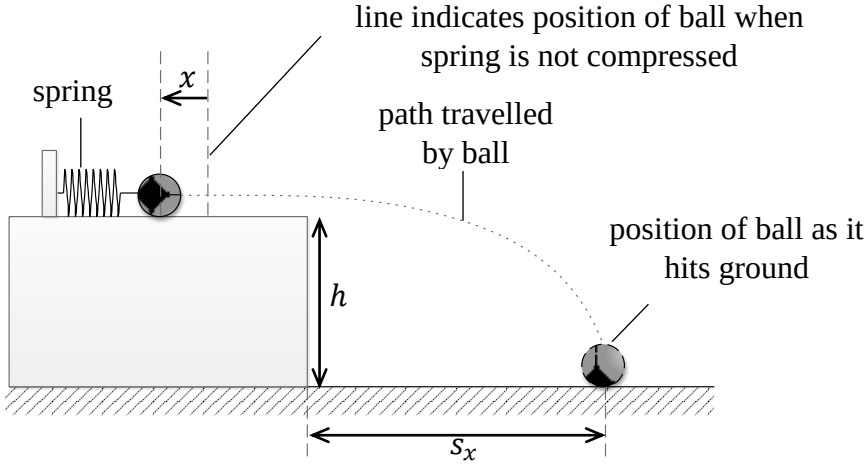


Figure 6

The student uses a ball of mass m equal to 0.10 kg and a spring having a spring constant k equal to 2.00 Nm^{-1}. The measured height h of the bench is 1.10 m. The equation relating the distance s_x and the velocity v with which the ball leaves the spring is given by:

$$s_x = v\sqrt{\frac{2h}{g}}$$

The velocity with which the ball leaves the spring is calculated using $v = x\sqrt{\frac{k}{m}}$.

Table 1

x /m	s_x /m	v
0.02	0.06	
0.04	0.08	
0.06	0.13	
0.08	0.16	
0.10	0.20	
0.12	0.26	
0.14	0.31	
0.16	0.34	

a. Copy Table 1 and fill in the missing values for *v*. (4)

b. Plot a graph of s_x on the y-axis against v on the x-axis. (5)

c. Use the graph to determine the value of the gravitational acceleration g. (3)

d. Suppose that the student performed the experiment from a bench whose height is lower than the one he used, how would this affect the gradient of the graph. (1)

e. Write down one precaution that is necessary to obtain accurate results. (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.

Question 10

a. Verify that the expression for centripetal acceleration has the correct units for acceleration. (1)

b. Figure 7 shows a simple pendulum that is made up of light string 0.80 m long and a bob of mass 1.20 kg. When the string makes an angle θ of 15° with the vertical, the bob is moving at $1.40\ \text{ms}^{-1}$.

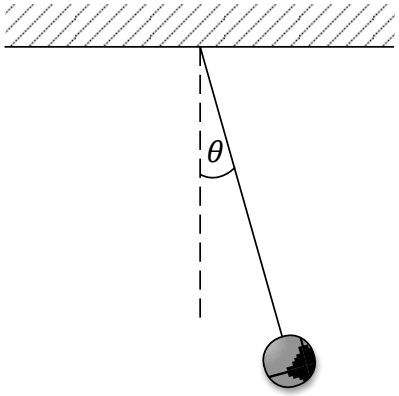


Figure 7

i. Draw a free body diagram showing the forces acting on the pendulum bob. (2)

ii. Calculate the centripetal acceleration of the bob. (2)

iii. Calculate the tension in the string. (3)

iv. Calculate the tangential acceleration of the bob. (2)

c. The International Space Station (ISS) travels around the Earth in the same direction as that of Earth, as shown in Figure 8. It takes 90 minutes to complete one orbit. Assume that the ISS performs a uniform circular orbit at an altitude of 400 km above Earth's surface. Take the Earth's radius to be 6.37×10^6 m.

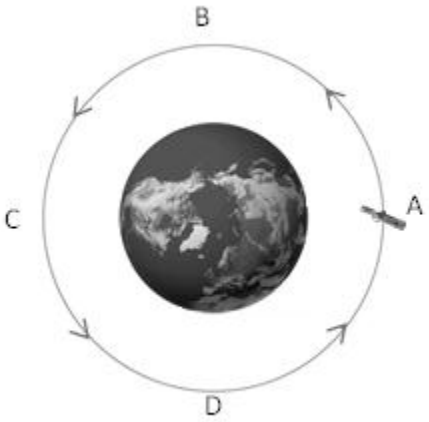


Figure 8

i. Copy the diagram and on it draw an arrow, labelled 'V' to indicate the direction of the ISS's instantaneous velocity at point D. (2)

ii. On the same diagram, indicate the direction of the ISS's instantaneous acceleration at point C and label it 'A'. (1)

iii. Calculate the total distance travelled by the ISS in one orbit. (2)

iv. Determine the ISS's instantaneous acceleration at point C. (3)

(Total: 18 marks)

Question 11

a. Two metal spheres are suspended by light strings. Sphere A has a charge of -5.0×10^{-8} C and sphere B has a charge of $+5.0 \times 10^{-8}$ C. A uniform electric field of 400000 N $C^{-1}$is applied and the two spheres separate as shown in Figure 9. The spheres are in equilibrium with their strings making an angle θ of 10° to the vertical. The spheres have a mass of 2×10^{-3} kg each.

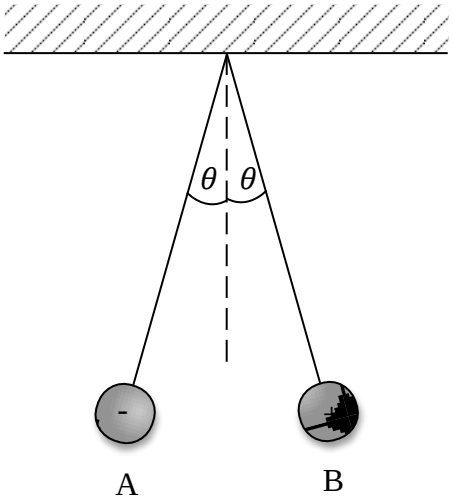


Figure 9

i. Copy the diagram and on it draw an arrow to indicate the direction of the electric field. Label this arrow 'E'. (2)

ii. Determine the tension in one of the strings. (2)

iii. Calculate the force on Sphere B due to the electric field 'E' alone. (2)

iv. Without using Coulombs' law, determine the force of attraction between the spheres. (5)

b. A proton, of charge 1.602×10^{19} C and mass of 9.1×10^{-31} kg, is projected upwards with a speed of 7.5×10^{5} m s^{-1} through a hole punched in a metal plate, as shown in Figure 10. A uniform electric field E in the space above the metal plate has a magnitude of 6.50×10^{4} N C^{-1}. The space above the metal plate is a vacuum.

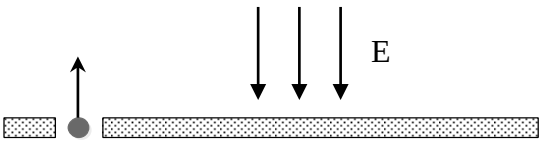


Figure 10

i. Calculate how far will the proton travel in the upwards direction before it is stopped by the electric field and turns to move downwards. (4)

ii. Can you neglect the force of gravity when solving for the vertical distance travelled by the particle? Explain. (3)

(Total: 18 marks)

Please turn the page.

Question 12

a. Distinguish between longitudinal and transverse waves. (2)

b. A sine wave is travelling to the right on a light cord. The solid line in Figure 11 represents the shape of the cord at time t = 0 s; the dashed line represents the shape of the cord at time t = 0.20 s.

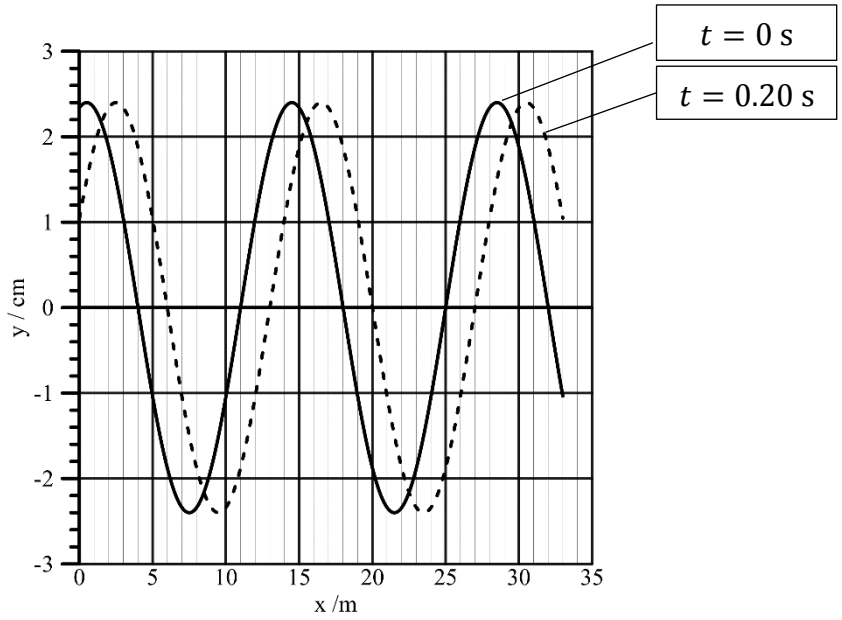


Figure 11

i. Determine the amplitude and wavelength of the wave. (2)

ii. Calculate the speed of the wave. (2)

iii. Determine the periodic time of the wave. (2)

c. Two fishing bobs, P and Q, stand 0.50 m apart when a water wave of wavelength 1.5 m passes the two bobs. The water wave has an amplitude of 0.30 m and is moving at 0.5 m s^{-1} to the left.

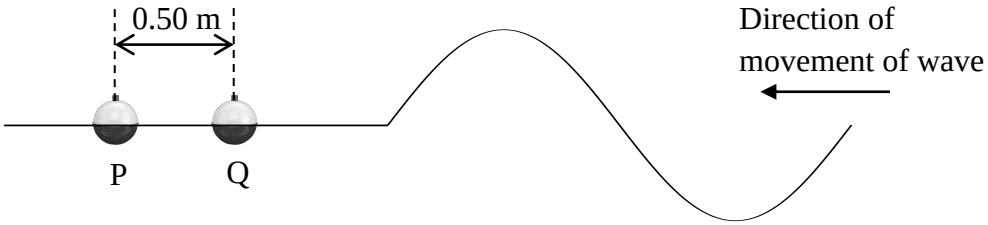


Figure 12

i. Sketch a displacement-position graph that shows the position of the two bobs at the instant when bob P is at the crest of the wave. The diagram should be clearly labelled. (3)

ii. Calculate the amount of time needed for the wave to reach bob P after hitting bob Q. (1)

iii. On a single displacement-time axis, sketch **TWO** curves that show how the vertical displacement of both bobs change with time. (4)

iv. Express the phase difference between the two graphs drawn in part (iii) as a fraction of the periodic time of the wave. (2)

(Total: 18 marks)

Question 13

a. It is possible for two objects A and B to be in thermal equilibrium even if they are not in thermal contact with each other. Explain this statement. (3)

b. A platinum wire is to be used as a thermometer.

i. Name the physical property of the platinum wire thermometer that changes considerably with temperature. (1)

ii. Describe briefly how a thermometer consisting of a platinum wire can be calibrated such that changes in its physical property can be converted to temperature readings. Your description should include:

- a list of the apparatus needed; (3)
- the measurements that need to be taken; (2)
- a description of how the temperature in degrees Celsius can be obtained from the measurements taken. (3)

c. The setup shown in Figure 13 shows a constant volume gas thermometer. The glass bulb containing the low pressure gas is placed in a container with water at 40 °C. The pressure of gas inside the bulb is the sum of the atmospheric pressure and the pressure exerted by the mercury coloumn. Assume that atmospheric pressure is 101 000 Pa.

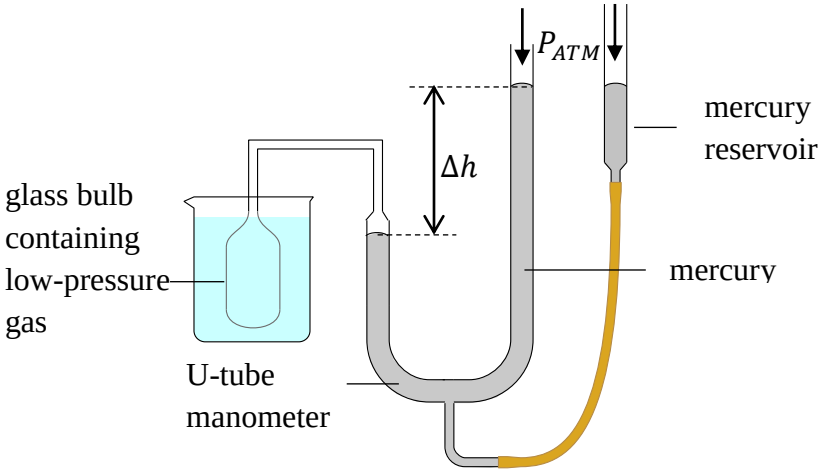


Figure 13

i. If the height of the mercury column Δh is 0.31 m and the density of mercury is 13600 kg m^{-3}, calculate the pressure of the gas inside the bulb. (2)

ii. The pressure of the gas when the bulb is placed inside boiling water is 198.40 kPa. Calculate the pressure of the gas inside the bulb when it is placed in a mixture of ice and water at 0°C. (4)

(Total: 18 marks)