



THE UNIVERSITY OF FIJI

SCHOOL OF SCIENCE AND TECHNOLOGY

FINAL EXAMINATION

SEMESTER II, 2013

PHYF 12: FOUNDATION PHYSICS II

Time Allowed: 3 hours

[An extra 10 minutes is allowed for reading this paper]

TOTAL: 100 MARKS (50% OF THE FINAL GRADE)

INSTRUCTIONS:

1. There are 7 questions in this paper.
2. **All the questions are compulsory.**
3. Answer each question on a new page and clearly number the questions attempted.
4. Show all working clearly. Partial marks will be allocated for appropriate and logical working.
5. Calculators are permitted, provided it is silent and non-programmable.
6. Unless otherwise stated, all symbols have their usual meanings.
7. If you use extra sheets of paper, attach it securely to the answer booklet.

Total number of pages: 10

DATA:

Acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$

Avogadro number, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

Mass of the Earth, $M_E = 5.98 \times 10^{24} \text{ kg}$

Radius of the Earth, $R_E = 6.38 \times 10^6 \text{ m}$

Specific heat capacity of ice, $c_{\text{ice}} = 2090 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$

Specific heat capacity of water, $c_{\text{water}} = 4186 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$

Universal gravitational constant, $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

Universal gas constant, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$

Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{ J/K}$

Rydberg's constant, $R = 1.097 \times 10^7 \text{ m}^{-1}$

Speed of light in a vacuum, $c = 3.0 \times 10^8 \text{ ms}^{-1}$

Coulomb's constant, $k = 9.0 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$

Charge on electron, $e = 1.6 \times 10^{-19} \text{ C}$

Electron mass, $m_e = 9.11 \times 10^{-31} \text{ kg}$

Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ Tm.A}^{-1}$

Question 1 (Start on a new page)

[17 Marks]

A. Differentiate between specular and diffused reflection.

[3 marks]

B. The roof top car park in the Sugar city mall has a convex mirror mounted on the wall to help people avoid collisions. The mirror has a radius of a curvature of 0.550 m.

i. Locate the image of a car 10.0 m from the mirror.

[2 marks]

ii. Determine the magnification.

[1 mark]

iii. Hence, describe the nature of the image.

[2 marks]

C. The human eye is one of the sophisticated natural optical instruments. One of the characteristics of the eye is *accommodation*. Define this term.

[2 marks]

D. John is nearsighted with the accommodation limits of 18.0 cm and 80 cm. When he wears his glasses, he is able to see distant objects clearly. At what minimum distance is he able to see objects clearly?

[3 marks]

E. The diagram shows the experiment on refraction of light.

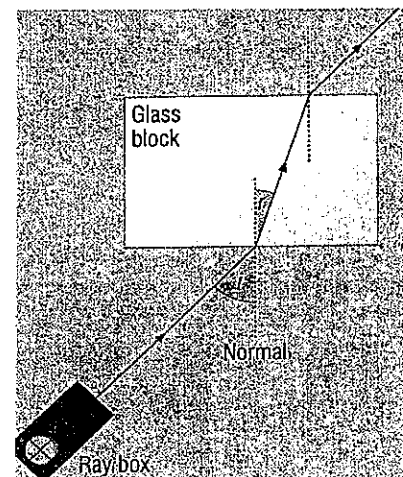
Using $n_{\text{air}} = 1.00$:

i. Compute n_{glass} when angle 'r' is 45° and angle 'i' is 28° .

[2 marks]

ii. Determine the critical angle of the glass block after which total internal reflection will occur.

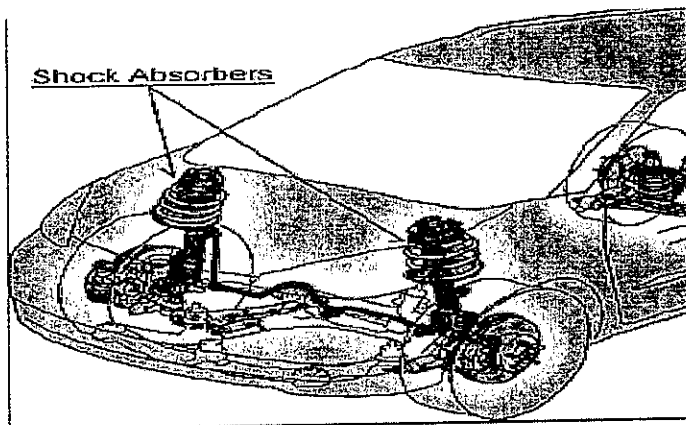
[2 marks]



Question 2 (Start on a new page)**[14 Marks]**

A. A car travelling at 10 m/s sounds its horn of frequency 800 Hz. A stationary listener, in front of the car hears the horn of the approaching car. What is the apparent frequency of the sound heard by the listener if the speed of sound in air is 320 m/s? [2 marks]

B. Explain why 'shock absorbers' are fitted to the suspension springs in the car? [2 marks]



C. A mass on a spring executes SHM with equation $x = 5.2 \cos(2\pi t + \frac{\pi}{4})$.

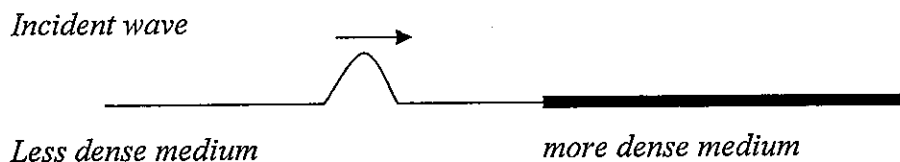
Determine:

- i) Period [1 mark]
- ii) Displacement at time $t = 1$ sec [2 marks]
- iii) The velocity at $t = 1$ sec. [2 marks]
- iv) The total energy of the mass if spring constant is 98.7 N/m. [2 marks]

D. A certain piano string is supposed to vibrate at a frequency of 4.40×10^2 Hz. In order to check its frequency, a tuning fork known to vibrate at a frequency of 4.40×10^2 Hz is sounded at the same time the piano key is struck, and a beat frequency of 4 beats per second is heard. Find the two possible frequencies at which the string could be vibrating. [3 marks]

Question 3 (Start on a new page)**[12 Marks]**

- A. When a wave travels from one medium to another, reflection and transmission of wave occurs. For the given case sketch the reflected and/or the transmitted pulse. [2 marks]



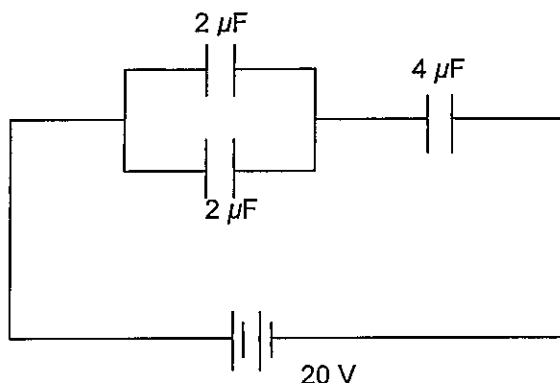
- B. A string vibrates in its fundamental mode of 40 Hz. The string is 50 cm long and both ends are fixed.

- Calculate the wavelength. [2 marks]
- Determine the speed of the wave in string. [2 marks]
- Sketch the first and second harmonics. [3 marks]
- Find the frequency for 1st and 2nd harmonics. [3 marks]

Question 4 (Start on a new page)**[19 Marks]**

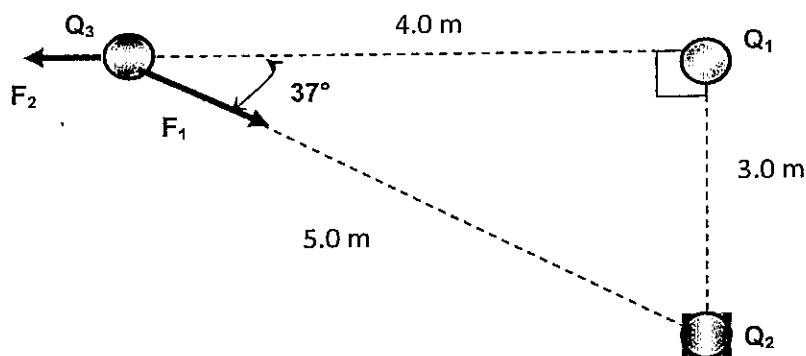
- A. Define *charge density*. [2 marks]

- B. Three capacitors have been connected as shown in the diagram.



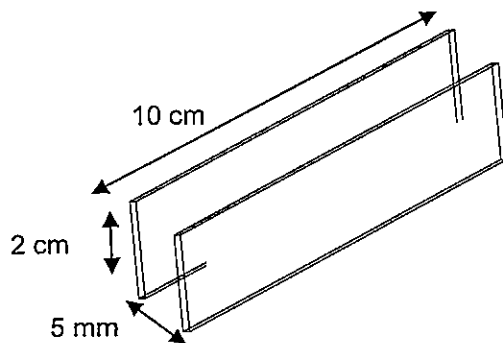
- Calculate the effective capacitance of the circuit. [2 marks]
- Calculate the charge supplied by the power supply. [2 marks]

- C. Q_1 , Q_2 , and Q_3 are three point charges placed at the corners of a right angled triangle as shown in the figure given below. The charges $Q_1 = 6 \text{ nC}$, $Q_2 = -2 \text{ nC}$ and $Q_3 = 5 \text{ nC}$.



- Find the force F_1 due to charge Q_2 on Q_3 . [2 marks]
- Find the force F_2 due to charge Q_1 on Q_3 . [2 marks]
- Hence or otherwise, find the resultant force on Q_3 by the other two charges. [3 marks]

- D. A parallel plate capacitor consists of two plates each 10.0 cm and 2.0 cm at a distance of 5.00 mm apart as shown below.



- If the space between the parallel plates is filled with air, find the capacitance of the capacitor. [2 marks]

If a potential difference of 1000 V is applied across the plates, calculate:

- The charge on each plate. [1 mark]
- The electric field strength between the plates. [1 marks]

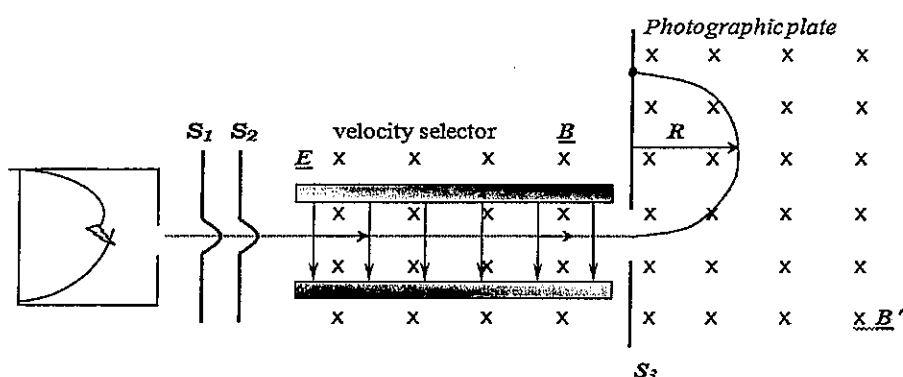
- iv) Now if Jone fills the space with Teflon a dielectric material with dielectric constant of 35, what would be the capacitance of this parallel plate capacitor?

[2 marks]

Question 5 (Start on a new page)

[19 Marks]

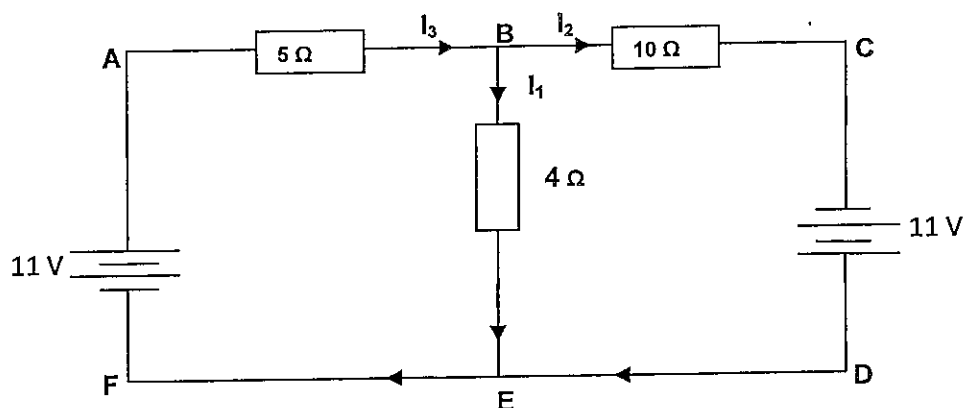
- A. The diagram given below shows the schematics of a mass spectrometer. The ions are sourced from a spark discharge in a certain gas which releases helium ions. The ions drift through a hole in the set-up and are given a required velocity by the velocity selector.



- What kind of charge is carried by the ions? [1 mark]
 - What would be the velocity of the ions if the electric field strength is $1.28 \times 10^5 \text{ Vm}^{-1}$ and the magnetic field strength is 0.04 T in the velocity selector? [2 marks]
 - Hence, calculate the mass of the ion if the radius of the path found on the photographic plate is 1.60 m, the charge of the ion is $3.2 \times 10^{-19} \text{ C}$ and the magnetic field strength is 0.04 T. [2 marks]
- B. Two parallel wires carrying currents of 2 A and 3 A respectively are placed 2 cm apart. Find the force per unit length on each. [2 marks]
- C. A transformer with negligible power loss is connected to a 120 V input. The primary coil has windings of 600 turns and there are 15000 turns in the secondary. Calculate the output voltage. [2 marks]

D. The resistivity of copper is $1.6 \times 10^{-8} \Omega\text{m}$. Calculate the resistance of a piece of copper of length 5 m and radius 0.010 cm. [2 marks]

E. Shown is a circuit of three resistors and two batteries.



- i) Using Kirchhoff's first law, write an equation for junction B. [1 mark]
- ii) Using Kirchhoff's second law, write equations for loop: [3 marks]
 - a) ABEFA
 - b) CDEBC
- iii) Use the equations obtained above to solve for currents I₁, I₂, and I₃. [4 marks]

Question 6 (Start on a new page)

[12 Marks]

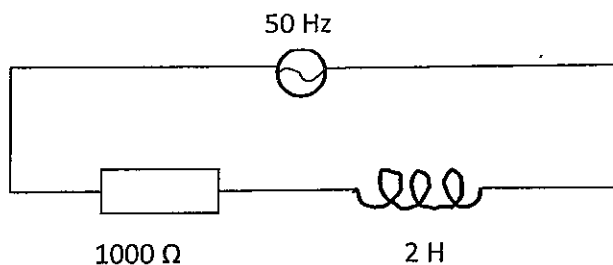
A. Define *resonant frequency* as in a LCR series circuit. [1 mark]

B. An electric appliance with a power rating of 2000 W is connected to a 240 V_{rms} household mains supply.

Calculate the:

- i) Peak (maximum) voltage, and [1 mark]
- ii) rms current passing through the appliance. [2 marks]

- C. An inductor of inductance 2 H and a 1 k Ω resistor are connected in series to a 50 Hz power supply. The rms current flowing in the circuit is 2.5 A as in the diagram given below.



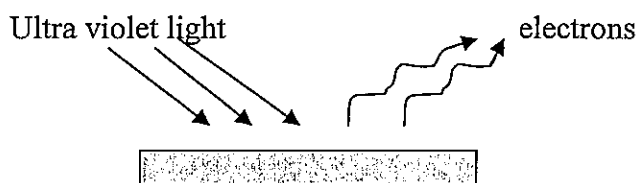
Determine:

- i) The voltage across the resistor. [1 mark]
- ii) The voltage across the inductor. [3 marks]
- iii) The supply voltage. [2 marks]
- iv) The impedance of the circuit. [2 marks]

Question 7 (Start on a new page)

[7 Marks]

- A. In 1913, using the simplest hydrogen atom, Neil Bohr proposed a theory that includes some features of the currently accepted theory of an atom. Bohr developed four postulates to explain his theory of the atom. State any two of these postulates. [1 mark]
- B. A metal surface is illuminated with ultraviolet light of wavelength 330 nm. Electrons are emitted from the metal surface. The minimum amount of energy required to emit an electron from the surface of this metal is 3.5×10^{-19} J.



- i. Name the phenomenon illustrated in the diagram on the previous page. [½ mark]
- ii. Give ONE word or term for the underlined sentence in the above paragraph.
[½ mark]
- iii. Calculate the frequency of the ultraviolet light. [2 marks]
- iv. Calculate the kinetic energy of a photoelectron emitted from the surface of the metal when the ultraviolet light shines on it. [2 marks]
- v. The intensity of the ultraviolet light illuminating the metal is now increased.
What effect will this change have on the following:
- a. Kinetic energy of the emitted photoelectrons (Write down only
INCREASES, DECREASES or REMAINS THE SAME.) [½ mark]
- b. Number of photoelectrons emitted per second (Write down only
INCREASES, DECREASES or REMAINS THE SAME.) [½ mark]

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