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The University of Fiji

School of Science and Technology

Department of Science

Semester II, 2019

Final Course Examination Paper

PHYF12: FOUNDATION PHYSICS II

Time Allowed: 3 hours

(An extra ten minutes is allowed for reading this paper)

Important Instructions to Students:

1. Read the questions, instructions carefully and answer the questions in the **Answer Booklet** provided.
2. There are **twelve (12)** pages (including this cover) page in this paper.
3. You are allowed an **extra 10 minutes reading time** (during this time, you are not allowed to write with pen) and **180 minutes (3 Hours)** to complete this paper.
4. Silent, non-programmable calculators are allowed, but not supplied.
5. Write all your answers in the answer booklet provided. If you need extra sheets, please ask from the supervisor. Write your name, course code and student identification number in the answer booklet and in the attendance sheet.
6. Write all your answers legibly. The marker has the right to award zero for answers that are not legible.
7. This is a closed book examination. The University views plagiarism, cheating and dishonest practice as serious offences and if found, offenders are penalized.
8. This Final Course Examination Paper is worth 100 marks and contributes 50% of the total course assessments.
9. There are two sections in this paper; Section A and B and **all the questions are compulsory**.

Section	Questions	Marks	Suggested Time
A	A1 – A10	20	36 minutes
B	1 – 8	80	144 minutes
Total		100 marks	180 minutes

DATA

Acceleration due to gravity, g	9.8 ms^{-2}
Coulomb's law, k	$9.0 \times 10^9 \text{ Nm}^2\text{C}^{-2}$
Charge of an electron and proton, e	$1.6 \times 10^{-19} \text{ C}$
Speed of light in vacuum, c	$3.0 \times 10^8 \text{ ms}^{-1}$
Speed of sound in air, v	345 ms^{-1}
Refractive index of water	1.33
Mass of electron, m_e	$9.11 \times 10^{-31} \text{ kg}$
Mass of proton, m_p	$1.67 \times 10^{-27} \text{ kg}$
Permittivity of free space, ϵ_0	$8.85 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$
Permeability of free space, μ_0	$4\pi \times 10^{-7} \text{ TmA}^{-1}$
Planck's constant, h	$6.63 \times 10^{-34} \text{ Js}$
Rydberg's constant, R	$1.097 \times 10^7 \text{ m}^{-1}$

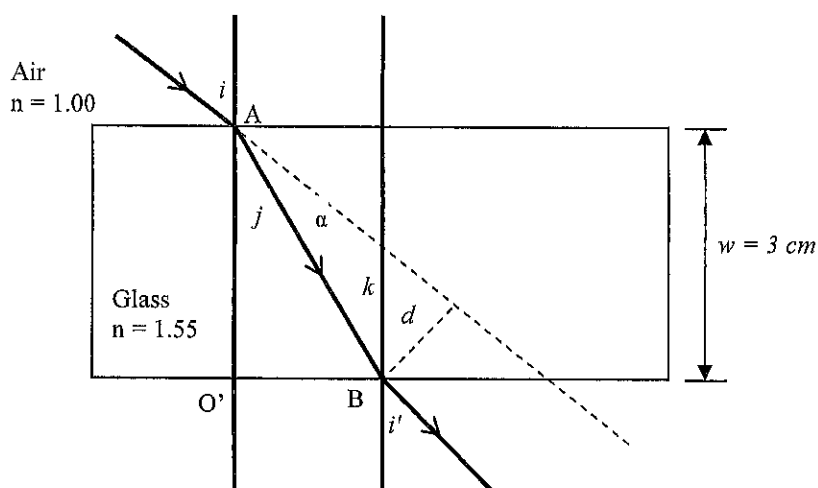
SECTION A: *Answer ALL questions in the Answer Booklet provided. Each question is worth 2 marks.* **[20 marks]**

- A1. When light travels from one medium to another, the path of light is affected due to the change in the optical density of the medium. Describe what happens to the speed of light as it travels from less dense to a denser medium and how is the path of the ray of light affected?
- A2. A camera used by a professional photographer to shoot portraits has a focal length of 20.0cm. The photographer takes a portrait of a person 120 cm in front of the camera. Where is the image formed, and what is the value of the lateral magnification?
- A3. A student attempts to use a simple pendulum to measure the value of the acceleration due to gravity, g . She observes that a pendulum of length 1.5 m makes 24 oscillations in 60 s. What is the value of ' g ' at her location?
- A4. At what angle does the first order maximum occur for green light of wavelength 550 nm incident on a grating with 12 000 lines per centimeter?
- A5. A parallel plate capacitor is 100 cm by 50 cm and the plates are separated by a distance of 10 cm. They are connected to a 12 V battery. Calculate the capacitance of the capacitor.
- A6. An aircraft has a wing span of 47 m and is flying horizontally at 250 m/s, the vertical component of the earth's magnetic field is 6×10^{-4} T. Calculate the induced emf between the aircraft wing tips.
- A7. State *Faraday's Law* and give an equation governing the law.
- A8. Describe how a mass spectrometer is used to isolate ions of different isotopes.
- A9. The refractive indices of materials A and B have a ratio of $n_A/n_B = 1.33$. The speed of light in material A is $1.25 \times 10^8 \text{ ms}^{-1}$. What is the speed of light in material B ?
- A10. An electron makes a jump from the second energy level ($n = 2$) to ground state ($n = 1$). Calculate the wavelength of the emitted photon.

SECTION B: There are *eight* questions in this section and *all* the questions are compulsory.
Each question is worth **10** marks. Answer each question on a new page in the
Answer Booklet. **[80 marks]**

Question 1

- a) A light ray strikes a homogeneous rectangular block of glass, of thickness w at an angle of incidence, $i = 32^\circ$. The ray emerges at point B at an angle, i' as shown in the diagram given below.



Calculate:

- i. The angle of refraction, j . [2 marks]
 - ii. The **lateral displacement**, d , the distance between the incident and the emerging rays as shown in the diagram given above. [3 marks]
- b) A dentist uses a spherical mirror to produce an upright image of a patient's tooth which is magnified by a factor of 4.5 when placed 1.8 cm from the tooth.
- i. What type of mirror - concave or convex - is being used? [1 mark]
 - ii. What is the focal length of the mirror? [2 marks]

- c) A car with bad shock absorbers bounces up and down with a period of 1.5 s after hitting a bump. The car has a mass of 1500 kg and is supported by four springs of equal force constant, k . Determine the value of k .

[2 marks]

Question 2

- a) A particle moving along the x – axis in simple harmonic motion starts from the equilibrium position, the origin, at time $t = 0$ and moves to the right. The position of the particle after time, t , is given by the following equation:

$$x = 2.0 \sin(3\pi t) \text{ cm}$$

Calculate:

- The maximum velocity of the motion.
- [1 ½ marks]
- The acceleration of the object after 2 seconds (i.e. at $t = 2$ s).
- [2 marks]
- The distance travelled by the particle from $t = 0$ s to $t = 2$ s.
- [2 marks]
- b) In the Wheatstone bridge circuit as shown below, R_1 and R_2 are 200Ω and 300Ω resistors. R_x is a resistor of unknown resistance.

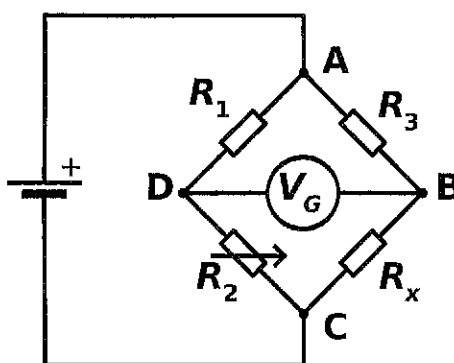


Image Source: https://en.wikipedia.org/wiki/Wheatstone_bridge#/media/File:Wheatstonebridge.svg

The bridge is balanced when R_3 is set to 180Ω . Calculate the resistance of R_x .

[2 marks]

- c) A copper wire of cross-sectional area $3 \times 10^{-6} \text{ m}^2$ carries a current of 10 A. The density of free electrons in copper is 8×10^{28} electrons per cubic metre.

i. Find the current density.

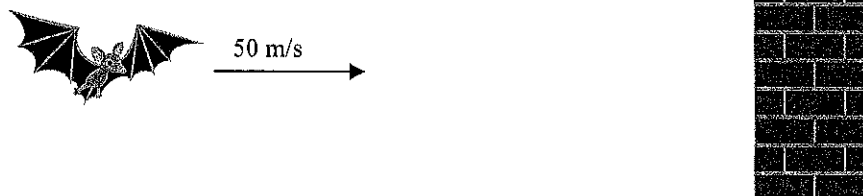
[1 mark]

ii. Calculate the drift velocity of the electrons.

[1 ½ marks]

Question 3

- a) A bat is flying towards a stationary wall at a constant speed of 50 m/s as shown in the diagram given below.



The bat emits a sound of 125 Hz towards the wall, which is then reflected back at the bat. If the speed of sound in air is 345 m/s, what is the apparent frequency of the sound that the bat hears?

[3 marks]

- b) A 0.5 kg object connected to a light spring with a spring constant of 20 Nm^{-1} oscillates on a frictionless horizontal surface with an amplitude of 3 cm. Calculate:

i. The total energy of the system, and

[2 marks]

ii. The speed of the object when the object is 2 cm from the equilibrium position.

[3 marks]

- c) Neils Bohr proposed a theory on the model of the atom. He used the simple hydrogen atom and developed four postulates to explain his theory. State *two* postulates that was used by Bohr to explain his theory.

[2 marks]

Question 4

- a) Transverse waves with a speed of 50.0 ms^{-1} are to be produced on a stretched string. This was achieved using a 5.00 m length of string with a total mass of 0.060 kg and a hanging mass, m , to provide tension on the string, as shown below.

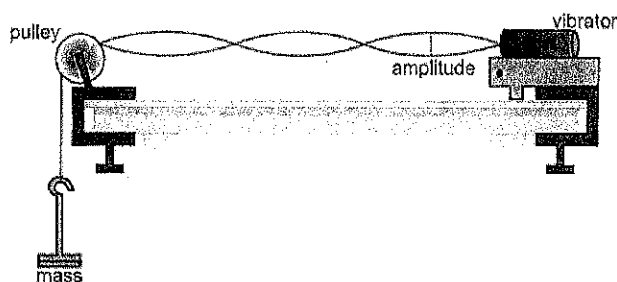
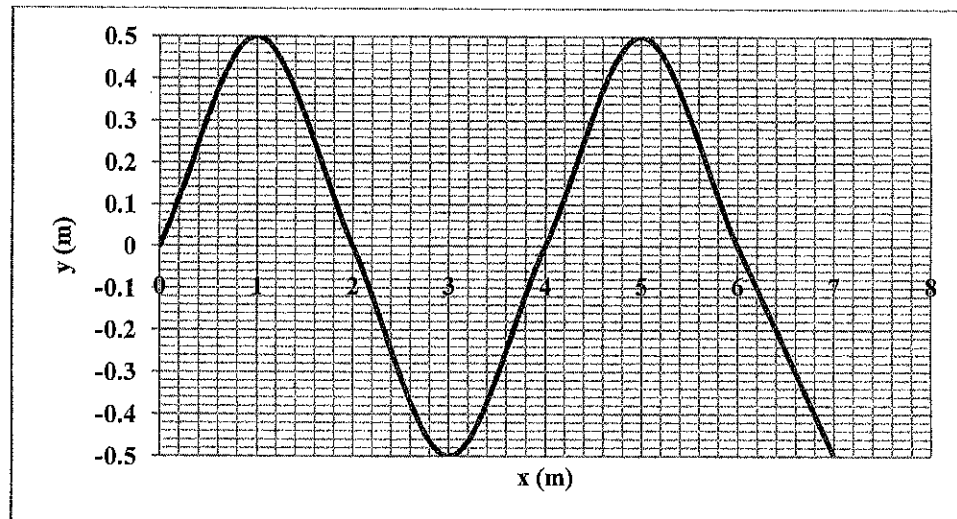


Image Source: http://www.webassign.net/question_assets/tamucalcphysmechl1/lab_10/manual.html

Calculate:

- i. The required tension in the string to achieve a speed of 50.0 m/s .
[2 marks]
 - ii. Calculate the speed of the wave in the string when the tension is 8.00 N .
[1 ½ marks]
- b) A parallel-plate capacitor is constructed using a dielectric material whose dielectric constant is 3.00 with an electric field strength of $2.00 \times 10^8 \text{ V/m}$ between the plates. The desired capacitance is $0.250 \mu\text{F}$, and the capacitor must withstand a maximum potential difference of $4\,000 \text{ V}$. Calculate:
- i. The distance between the plates.
[1 mark]
 - ii. The area of the plates of the capacitor.
[2 marks]

- c) A wave is travelling towards right as shown in the diagram given below; the particles in the wave vibrate at a frequency of 10 Hz.

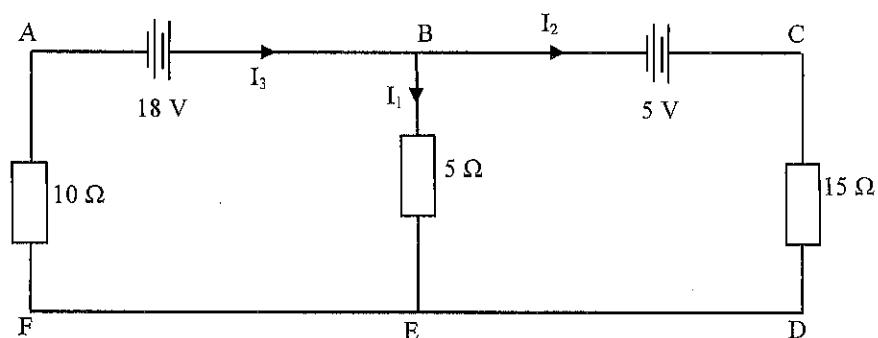


Determine the:

- Velocity of the wave. [1 mark]
- Wave number. [1 mark]
- Equation of the travelling wave. [1 ½ marks]

Question 5

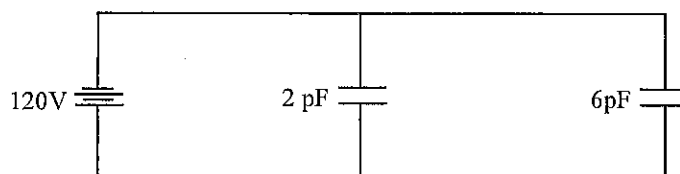
- a) A circuit consists of three resistors and two batteries as shown in the diagram given below.



- i. Using Kirchoff's junction rule, write an equation for the current at junction **B**.
[1 mark]
 - ii. Using Kirchoff's loop rule, write equations for the loops:
Loop: **ABEFA**
Loop: **BCDEB**
[2 marks]
 - iii. Use the equations obtained in **part ii**, to solve for the values of the currents I_1 , I_2 , and I_3 .
[3 marks]
- b) A **square** solenoid of 50 turns of wire and sides 0.05 m long is placed perpendicular to a magnetic field of strength 0.5 T.
- i. Determine the flux passing through the coil.
[1 mark]
 - ii. The magnetic field is reduced to zero during a time of 0.1 s. What is the induced voltage in the solenoid?
[1 ½ marks]
 - iii. If the current changes from zero to 2 A in 0.1 s, calculate the inductance of the coil.
[1 ½ marks]

Question 6

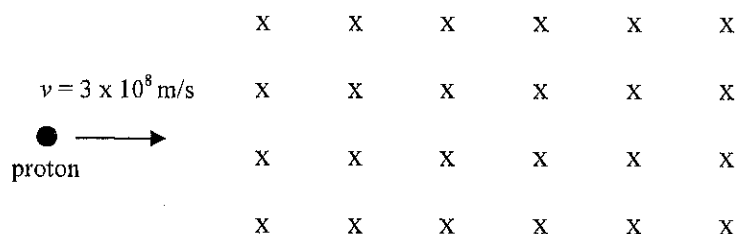
- a) A 2 pF and 6 pF capacitors are connected to a 120 V power supply in parallel.



Calculate:

- i. The total equivalent capacitance of the circuit.
[1 ½ marks]
- ii. The total charge coming out of the power supply.
[1 ½ marks]
- iii. The charge on each capacitor.
[2 marks]

- b) A proton of mass 1.6×10^{-27} kg and charge of 1.6×10^{-19} C travelling at a speed of 3×10^8 m/s enters a region of magnetic field, of strength $B = 0.03$ T as shown in the diagram given below.

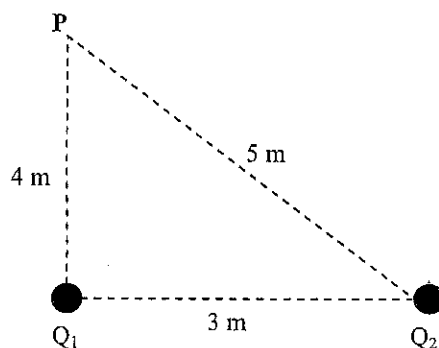


- i. Describe what will happen to the proton as it enters the magnetic field and determine the direction of the force on the proton in the magnetic field. [1 ½ marks]
 - ii. Calculate the radius of the motion of the proton in the magnetic field. [1 ½ marks]
- c) A wooden ring of mean diameter 0.1 m is wound with a closely spaced toroidal winding of 500 turns. Compute the field at a point on the mean circumference of the ring when the current in the windings is 0.3 A. [2 marks]

Question 7

- a) An initially uncharged capacitor, $C = 1.8 \mu\text{F}$ is being charged by a device of constant emf, $\mathcal{E} = 12.0$ V, connected in series with a resistor, $R = 1.4 \text{ M}\Omega$.
- i. Define what is meant by the term time constant, τ [1 mark]
 - ii. Calculate the time constant of the circuit. [1 ½ marks]
 - iii. Find the charge in the capacitor at $t = 17.0$ s. [2 marks]

- b) A $-0.60\ \mu\text{C}$ point charge, Q_1 , is at the origin and a point charge of $1.0\ \mu\text{C}$, Q_2 , is 3 m away from the origin on the x-axis as shown in the diagram below.

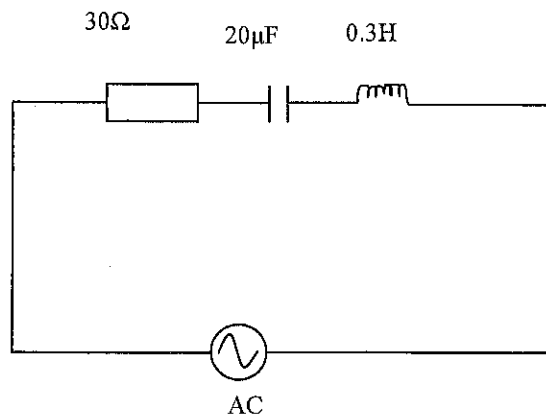


- Calculate the electric field strength at P due to charges Q_1 and Q_2 .
[4 marks]
- A third charge of $3.0\ \mu\text{C}$ is introduced at point P , determine the force experienced by the third charge due to charges Q_1 and Q_2 .
[1 ½ marks]

Question 8

- When blue light of wavelength 450 nm is incident on a metallic surface, electrons are emitted with a maximum kinetic energy of 1.31 eV.
 - Determine the minimum energy required for the electrons to be emitted from the metal.
[2 marks]
 - Find the cut-off wavelength of the metal
[2 marks]
 - Explain whether electrons will be emitted from the metallic surface described above if light of frequency 5×10^{14} Hz was incident on the surface?
[1 mark]

- b) A $20\ \mu\text{F}$ capacitor, a 0.3H inductor and a $30\ \Omega$ resistor are connected in series as shown in the diagram given below.



If the AC source has a terminal rms voltage of $240\ \text{V}$ at $50\ \text{Hz}$. Calculate:

- The reactance of the inductor and the capacitor.
[2 marks]
- The impedance of the circuit.
[2 marks]
- The rms current in the circuit.
[1 mark]

THE END