FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING SCIENCE AND TECHNOLOGY

Faculty of Science, School of Sciences, Department of Physics

EEE405: ENGINEERING SCIENCE

FINAL EXAMINATION – Semester 2, 2015
(Samabula Campus)

Date: 18-11-15 Time: 9:00 am -12:10 pm

Time Allowed 3 hours plus 10 minutes reading time

100 marks (50% of the total)

Requirement: Score a minimum of 50% to pass the course

Instructions to students:

1. This question paper is divided into **THREE** sections:

SECTION A: Multiple Choice	This section contains 8 questions. **All questions are compulsory.** Select only one of the choices as your answer.	**8 marks**
SECTION B: Short Answer questions	This section contains 10 questions. **All questions are compulsory.**	**20 marks**
SECTION C: Long Answer questions	This section contains 6 questions. **All questions are compulsory.**	**72 marks**

2. This examination paper contains 8 pages including the cover page.
3. Write your answers in the Answer Booklet provided.
4. Any extra sheets used must be secured to the Answer Booklet.
5. This is a close book examination.
6. Non-programmable calculators are allowed.
7. A list of Physical Constants & Formulae is provided on the next page. Use all relevant data and constant values from this list.

LIST OF PHYSICAL CONSTANTS & FORMULAE

Unless otherwise stated, use acceleration due to gravity = 9.8 m s^{-2}

Boltzmann constant = 5.6696 × 10^{-8} W m^{-2} K^{-4}

Coefficient of linear thermal expansion of concrete = 12 × 10^{-6} $°C^{-1}$

Emissivity of concrete = 0.7

Speed of light in vacuum c = 3.0 × 10^{8} m s^{-1}

Speed of sound in air at 0 °C = 331 m s^{-1}

K-band frequency range = 18 GHz – 26 GHz

SECTION A. Multiple Choice [8 MARKS]

A1. A certain physics textbook cover has length and width dimensions as 30.6 cm and 21.6 cm respectively. The surface area of the textbook cover is:

[1 mark]

(a) 104.4 cm
(b) 104.4 cm^2
(c) 690.96 cm^2
(d) 660.96 cm^2

A2. The same textbook from A1 above has a mass of 0.985 kg and a thickness of 25 mm. The density of the textbook is approximately:

[1 mark]

(a) 0.006 g mm^{-3}
(b) 5.960 g cm^{-3}
(c) 0.006 kg cm^{-3}
(d) 596 kg m^{-3}

A3. Which one of the following traveling waves has the largest speed?

[1 mark]

(a) $y = 8 \sin (2x + 15t)$
(b) $y = 2 \sin (3x - 15t)$
(c) $y = 8 \cos (4x + 20t)$
(d) $y = 7 \sin (6x - 24t)$

A4. For an object placed between F and C in front of a concave mirror, which one of the following provides the correct description of the image?

[1 mark]

(a) The image is real, inverted, and magnified
(b) The image is real, upright, and magnified
(c) The image is real, inverted, and diminished
(d) The image is real, inverted, and same size

A5. Which factor below correctly determines the color of electromagnetic radiation?

[1 mark]

(a) speed
(b) frequency
(c) wavelength
(d) all of the above

A6. The S.I. unit to record temperature is

[1 mark]

(a) degrees Celsius
(b) Kelvin
(c) Fahrenheit
(d) Candela

A7. The transfer of energy from molecule to molecule is called **[1 mark]**

(a) convection
(b) radiation
(c) conduction
(d) equilibrium

A8. In which of the following mediums would you expect the speed of sound to be the highest? **[1 mark]**

(a) air
(b) seawater
(c) kerosene
(d) copper

SECTION B. Short Answer Questions [20 MARKS]

B1. (i) Define *mass*.
(ii) List at least 2 significant differences between *mass* and *weight*. **[2 marks]**

B2. Briefly define what a *rigid* body is and also state how it differs from an *elastic* body. **[2 marks]**

B3. Differentiate between longitudinal and transverse waves. **[2 marks]**

B4. List the conditions for constructive interference of mechanical waves. **[2 marks]**

B5. Why do some emergency vehicles have the symbol AMBULANCE written on the front? **[2 marks]**

B6. What is a lens? **[2 marks]**

B7. Differentiate between natural convection and forced convection. **[2 marks]**

B8. A solar furnace can be constructed by using a concave mirror to reflect and focus sunlight into a furnace enclosure. What factors in the design of the reflecting mirror would guarantee very high temperatures? **[2 marks]**

B9. (i) Does boiling water at 100 °C possess more heat energy than steam at 100 °C?
(ii) Which property of water helps to determine which state of water possesses more heat energy? **[2 marks]**

B10. One way to tell if a mosquito is about to sting is to listen for the Doppler shift as the mosquito is flying. The buzzing sound of a mosquito's wing is emitted at a frequency of 1050 Hz. If you hear a frequency of 1034 Hz, does this mean that the mosquito is coming in for a landing or that it has just bitten you and is flying away? Explain your answer. **[2 marks]**

SECTION C. Long Answer Questions [72 MARKS]

C1. (a) A car travelled for 6 hours and covered a total distance of 360 km.
(i) What was the average speed of the car in km hr^{-1}?
(ii) If at the end of the trip the car was exactly 60 km from its starting point, calculate the average velocity of the car.

[4 marks]

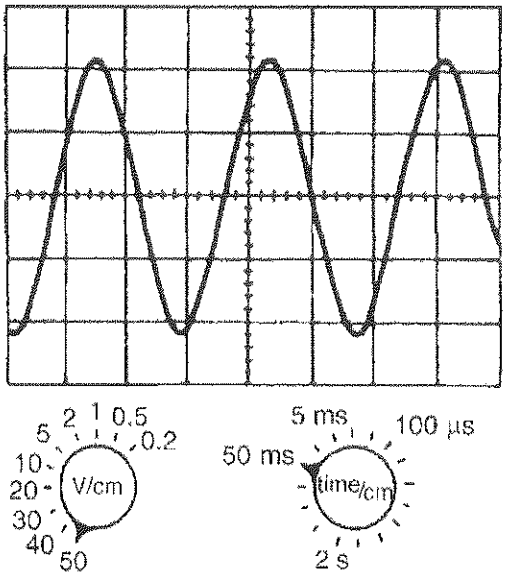
(b) Define *average acceleration.* **[2 marks]**

(c) A footballer kicks a football from rest to a speed of 10 m s^{-1} during the time in which his toe is in contact with the ball (about 0.20 s).
(i) Determine the average acceleration of the football.
(ii) If the football has a mass of 0.50 kg, calculate the average force the footballer exerts on the ball.
(iii) Does the football exert any force on the footballers' toe? Explain your answer.

[6 marks]

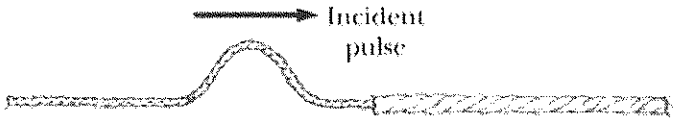
C2. (a) A certain traveling wave is described by $y = 2.00$ cm sin $(kx - vt)$, where $k = 2.11$ rad m^{-1}, $v = 3.62$ rad s^{-1}, x is in meters, and t is in seconds. Determine the:
(i) wavelength,
(ii) frequency,
(iii) speed, and
(iv) direction of the traveling wave. **[4 marks]**

(b) For the oscilloscope voltage waveform in the Figure below, assume the grid shown is made up of 1 cm × 1 cm boxes. The display controls shown below are the calibrations of the oscilloscope. The settings of the waveform can be interpreted from the controls.



For this waveform, determine the:
(i) time period,
(ii) peak-to-peak voltage,
(iii) r.m.s. voltage. **[6 marks]**

(c) For the incident traveling pulse shown in the Figure below, sketch the reflected and transmitted pulses after the incident pulse completely crosses the region of adjoining strings. Clearly label the reflected and transmitted pulses.



[2 marks]

C3. (a) Define refraction of light. **[2 marks]**

(b) Sketch and illustrate critical angle of reflection and show that it can be written:

$$\theta_C = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

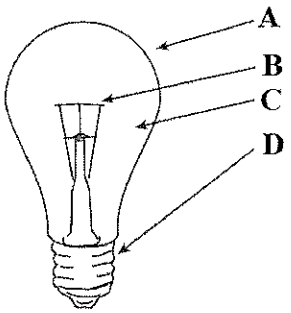
Where symbols have their usual meaning. Discuss how this equation leads to the total internal reflection, describe the significance of the total internal reflection and highlight three Engineering applications of it with reference to their use in Fiji.

[6 marks]

(c) A glass fiber with refractive index $n = 1.50$ is submerged in water with refractive index $n = 1.33$.
(i) Determine the critical angle.
(ii) Calculate the speed of light traveling in this glass fiber.

[4 marks]

C4. (a) In the Figure shown below, the main parts of an incandescent lamp are labeled with alphabets. Correctly name these main parts. **[2 marks]**



(b) A 60 W incandescent light bulb has a luminous flux of 1000 lm. Assume that light is emitted isotropically from the bulb.
(i) What is the luminous efficiency (i.e. the number of lumens emitted per watt of electrical input power) of the light bulb?
(ii) What is the luminous intensity, I_{lum}, in units of candela, of the light bulb?
(iii) What number of standardized candles emit the same luminous intensity?
(iv) Derive the relationship between the illuminance at a distance r from the light bulb, measured in *lux*, and the luminous intensity, measured in *candela*.

(v) What is the illuminance, E_{lum}, in units of lux, on a desk located 1.5 m below the bulb?

[10 marks]

C5. (a) (i) Define temperature.

(ii) Clearly state the relation between heat and temperature.

[4 marks]

(b) (i) The average coefficient of linear thermal expansion is defined as the fractional change in length per degree of temperature change. Using this information, write an expression for the change in length in terms of the initial length and temperature change.

(ii) A road engineer is designing a new superhighway. The concrete sections of the superhighway are considered to have a length of 25 m. The sections are to be poured and cured at 10 °C. What minimum spacing should the road engineer leave between the sections to eliminate buckling if the concrete is to reach a temperature of 50 °C?

(iii) Determine the amount of heat energy lost through radiation by a section of the concrete slab 25 m × 2 m in one hour.

[8 marks]

C6. (a) Define Doppler effect.

[2 marks]

(b) Using the general relationship for Doppler effect observed frequency, derive an expression for the velocity of the source.

[4 marks]

(c) One application of Doppler effect is in the police radar, which the policeman uses to catch traffic offenders. One such police radar, which transmits pulsed signals at the lowest end of the K-band frequency, is used in the Nakasi area where the speed limit is 50 km hr^{-1} (13.89 m s^{-1}). On a hot day when the air temperature is 35 °C, a policeman sends a pulsed signal at an approaching car and Doppler frequency at the radar receiver is 18.6 GHz.

(i) Determine the speed of sound in air of temperature 35 °C.

(ii) Determine the speed at which the car approaches the policeman.

(iii) Is the car within the speed limit or is it over-speeding? Explain your answer.

[6 marks]

THE END