UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester Examination in Engineering: June 2014

Module Number: EE5317

Module Name: Sensors, Transducers and Measurement Techniques

[Two Hours]

[Answer **all questions**, questions 1 and 3 carries 6 marks each, question 2 carries 3 marks and question 4 carries 5 marks]

Q1

a) Figure Q1 a) shows the structure of a MEMS device

i. What does the acronym MEMS stand for?

ii. What parameter does this device measure?

iii. Why are the 0° and 180° phase differences necessary in the sensing elements?

[2 Marks]

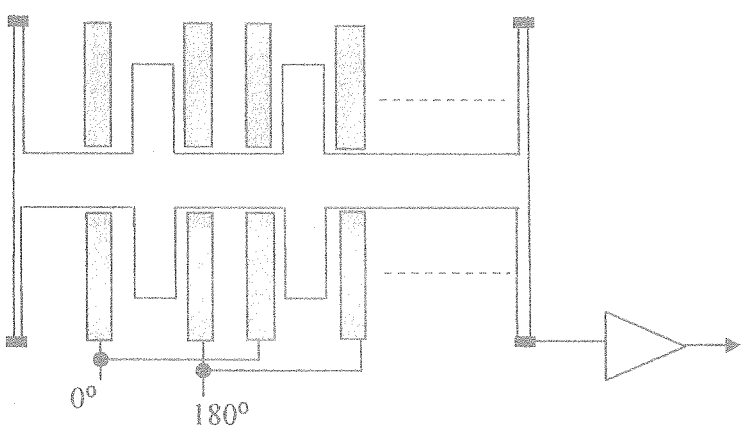

Figure Q1 a)

b) i. What device would you use to measure earths vibrations?

ii. Sketch the structure of a mechanical device that can be used to measure this parameter.

iii. Sketch the characteristic curve for this device and show its operating region.

[2 Marks]

c) i. What device would you use to measure rotation?

ii. Define the force that governs the behaviour of such a device.

iii. Sketch the structure of a MEMS device that measures rotation and briefly explain its operation.

[2 Marks]

Q2

a) i. Briefly describe the three effects associated with thermoelectricity?

ii. Figure Q2 a) shows a thermoelectric circuit. How is this circuit used as a temperature sensing thermocouple and a thermoelectric cooler.

[1.5 Marks]

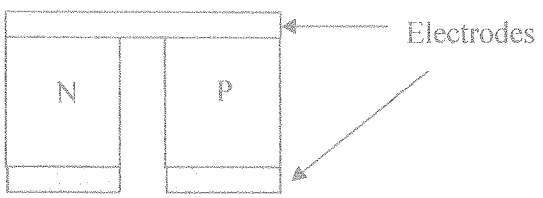

Figure Q2 a)

b) i. What does the acronym RTD stand for in a RTD temperature sensor?

ii. What is the principle under which a RTD operate?

iii. Sketch a two wire RTD circuit and explain why there may be errors when this configuration is used for temperature measurements.

iv. Give an alternate configuration for minimizing these errors.

[1.5 Marks]

Q3

a) i. State a necessary condition for the propagation of acoustic waves.

ii. Which type of acoustic waves propagates in air?

iii. How do these waves propagate?

iv. What is the speed of these waves?

v. What is the audible frequency range of acoustic waves in air?

[1 Mark]

b) i. Which type of acoustic wave propagates in water?

ii. What is the speed of these waves in water?

iii. Ceramic elements used for constructing acoustic transducers are not piezoelectric in their natural state. Why is this?

iv. A piezoelectric disk has a diameter of 25 mm and a thickness of 2 mm. If the compressional and shear speeds of the piezoelectric material are 3700 m/s and 2100 m/s respectively, what is the operating frequency of the disk?

v. Sketch the structure of a transmitter/receiver constructed using this disk to propagate short pulse acoustic waves in water.

[2 Marks]

c) i. State the three types of elastic waves that propagate in a solid.
ii. Which law governs the propagation of these waves in a solid?
iii. The transducer in b) v) can be used to generate the elastic waves in a solid to detect a defect. However, this can give confusing results in measurements. Why is this?
iv. Describe how Snell's Law can be utilized to design a structure that is more suitable for crack detection in a solid.

[3 Marks]

Q4

a) Rewrite the following results in their clearest forms, with suitable number of significant figures.

measured height $= 5.03 \pm 0.04329\ m$

measured wavelength $= 0.000{,}000{,}563 \pm 0.000{,}000{,}07$ m

measured charge $= 5.33 \times 10^{-7} \pm 3.21 \times 10^{-9}$C

measured momentum $= 3.267 \times 10^{3} \pm 42$ gcm/s

[1 Mark]

b) Two students measure the length of the same rod and report the results as 135 ± 3 mm and 137 ± 3 mm.
i. Represent these two measurements in a discrepancy diagram.
ii. Calculate the discrepancy between the two measurements.
iii. Is it significant?
iv. What is your conclusion about these two measurements? [1 Mark]

c) To find the area of a rectangular plate, a student measures its sides as $l = 9.1 \pm 0.1$ cm and $b = 3.3 \pm 0.1$ cm
i. Express these uncertainties as percent uncertainties.
ii. Find the area, with its uncertainty.

[1.5 Marks]

d) A student measures g, the acceleration of gravity, five times, with the results (all in m/s2): 9.9, 9.6, 9.5, 9.7, and 9.8.
Find the mean and the standard deviation.

[1.5 Marks]