Sir Arthur Lewis Com
Division of Technical Education and Management Studies

Final Examination MAY 2015

PROGRAMME TITLE(S)	:	Computer System Engineering; Electronic Engineering Automotive Engineering, Mechanical Engineering
PROGRAMME CODE(S)	:	3EE-CSE-AD 3EE-ESC-AD 3ME-MEC-AD 3ME-AUT-AD
COURSE TITLE	:	Applied Engineering Science 1
COURSE CODE	:	ESC103
DURATION	:	3 HOURS
TIME	:	1:00 p.m.
DATE	:	Monday 18th May 2015
ROOM	:	CEHI-0R-01
COURSE TUTOR	:	Mr. Narpaul Heeralall; Mr. Florian Combie
INVIGILATOR(S)	:	**Ms. E. Lewis**; C. Alexander; P. Wilson

Students ID Number	:										

INSTRUCTIONS

1. This paper has **TWELVE** questions. All questions carry twelve(12) marks
2. You are to answer **EIGHT QUESTIONS – no more than FOUR** from each section.
3. Ensure your answers and pages are numbered correctly
4. You will be rewarded for neat clear explanations and presentation.
5. Ray diagrams MUST be neat and clear.
6. Do all work in blue or black ink pen.
7. Ensure that you complete the table at the bottom of this cover sheet and attached to your answer booklet.
8. A **Formulae Sheet** is attached

DO NOT TURN THIS COVER SHEET UNTIL YOU ARE TOLD TO DO SO

Write the numbers of the questions you attempted in this table and attach it to your answer booklet

Questions								
Marks								

SECTION A

Question 1

a) State three conditions that must exists for a system to be defined as a **Simple Harmonic Oscillator**. State one limitations. [2]

b) A cantilever spring, fixed at one end, has a mass attached to the free end. When the cantilever is given a small deflection, it was observed to oscillate at a rate of 45 cycles per minute. When an additional 160g mass is attached to the spring, it oscillated at a rate of 25 cycles per minute.

Calculate the spring constant [4]

c) If the cantilever (*with all the mass*) is released from a deflection of 12cm:

i. Calculate the Potential energy stored in the system. [1]
ii. What is velocity of the mass as it passes the equilibrium point? [1]
iii. What is the velocity of the mass at a distance of 8cm from the equilibrium point? [2]
iv. Calculate the displacement at a time t = 0.5 second. [2]

Question 2

a) If the tension in a fixed string was increased by 3.5%, what will be the corresponding change in the velocity of the wave of the fundamental. [3]

b) Produce the diagram for the standing wave of the first overtone in a string and a closed pipe. [2]

c) A pipe closed at one end is 50 cm long. A violin is positioned near the open end and the string plucked. The violin string is 75 cm long and has a mass of 3g. The string vibrates in its second harmonic and produces a third harmonic standing wave in the closed pipe. The speed of sound in air is 340 m/s, determine:

i. the wavelength of the sound in the closed pipe [2]
ii. the frequency of the sound produced in by the closed pipe [2]
iii. the velocity of the wave generated in the violin string [1]
iv. the tension in the violin string [2]

Question 3

a) Two dog whistles when blown individually are inaudible, however when blown together produced a audible sound of frequency 7000 Hz. If one whistle is known to produce a sound of 22000Hz, what must be the frequency of the other? [2]

b) From the many long days waiting for fish, a fisherman observes that the waves at a particular location occur at a rate of 20 waves per minute and the distance between crests is 7.2 meters. If when heading directly towards shore, the waves seem to impact the boat at a rate of 15 "hits" per minute, then determine the following.

i. What is the speed of the waves at the location? [2]

ii. Estimate the speed at which the boat was travelling? [2]

c) A fisherman sitting in his boat hears two sounds of an explosion 2.5 seconds apart.
   i. Explain the presence of two sounds. [2]
   ii. If a fainter sound of the explosion was observed 0.5 seconds after the first, what is an explanation for this "middle" sound. [2]
   iii. Given that the temperature of the air was 22°C, calculate how far away did the explosion occur. [2]

speed sound in air is 331m/s at $0^{o}C$
speed of sound in sea water is 1560m/s

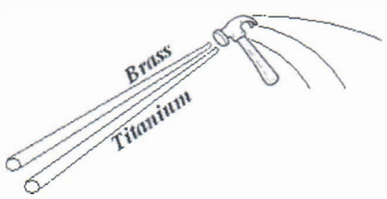
Question 4

a) Two electronics students listening to an oscillator producing a note through a speaker observed the note becoming more and more difficult to hear. The first student said that "**the sound was going beyond the human audio frequency range**". The second responded that "**the sound was going beyond the threshold of hearing.**" Explain the basis for each student making his particular conclusion. [4]

b) Explain the observable evidence that sound is a wave [2]

c) Explain the following terms
   i. Transverse wave [1]
   ii. Standing wave [1]
   iii. Resonance [1]
   iv. Echo location [1]

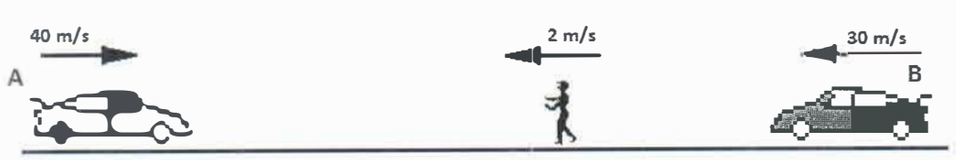
d) Two rods, one brass and the other titanium, of identical dimensions are struck by a hammer blow at one end. Which rod will the vibration reach the other end first and by what ratio will the speed of the vibration travel along the rods? [2]



Density of Brass 8525kg/m^2 Bulk Modulus of elasticity of Brass 330 kN/mm^2
Density if Titanium 4500kg/m^2 Bulk Modulus of elasticity of Titanium 330 kN/mm^2

Question 5

a) An observer standing on the railway platform notices that as a train leaves the platform, the pitch of the sound is different to the pitch as when it was at the platform. Using suitable diagrams explain this effect. Develop the formula that represents the frequency that the observer hears, from the departing train. [6]



b) The diagram above represent two cars A and B approaching a jogger along the road. In order to alert him of their presence they sound off their horns. Car B's horn produces a note of 1000 Hz and car A's horn produces a note of 550 Hz. The Jogger hears two distinct notes. Identify the notes and calculate their values. The temperature of the atmosphere at the time was 25° C. [6]

Question 6

A person standing a distance of 70m from seven equally loud speaker, experiences a Loudness at a level of 70 dB.

a) What loudness (dB) will the person experience, if only one speaker was left on? [4]

b) How far away should the person stand to experience the 70 dB, with only one speaker on (operating). [4]

c) With all speakers on, where should the person stand to experience a loudness of 65 dB. [4]

SECTION B

Question 7

a) An object, when placed a certain distance from a spherical mirror of focal length 15cm, produces a real image three(3x) times the height of the object

i. Sketch a ray diagram to show details of the image formed. [3]
ii. Calculate the distance between the object and the image formed. [4]
iii. If the object is moved 7 cm towards the mirror, state the characteristics of the image formed [2]

b) An object 3 cm tall and 30 cm away from a convex mirror of focal length 20 cm. Draw the ray diagram to locate the image. [3]

Question 8

a) The Young's double slit experiment employed ***monochromatic*** light source, a barrier with ***an initial slit*** followed a second barrier with ***two slits,*** then the screen. In the statement above, explain the significance of the items highlighted items and why was it important to the experiment. [3]

b) Two radar transmission towers located 6.4 km apart emit identical signals in phase with each other. A ship located at a point 30 km equidistant from the towers experiences a strong signal from the towers. However, as it sails parallel to the line of the towers it experiences an alternating diminishing and re-strengthen of the signal strength. If the distance between central (strong) signal and the next strong signal is 3.2km then:

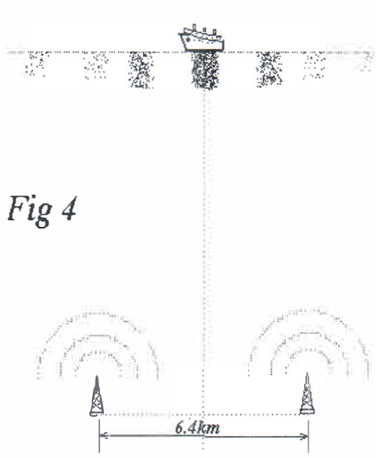


Fig 4

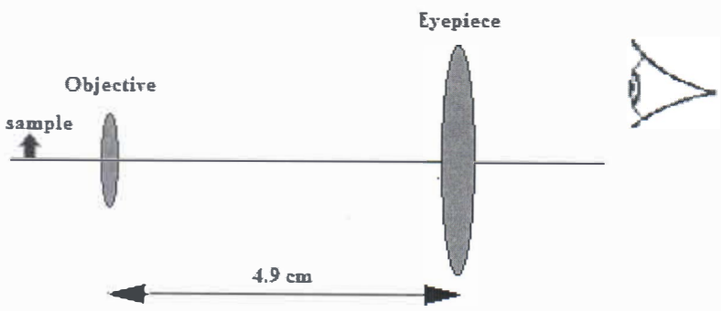
i. Calculate the wavelength and frequency of the signal emitted by the towers. [5]

ii. What would be the limitations of using such a signal for a mountainous terrestrial application? [1]

c) What would be the effect on the distance between strong signals if:
i. The distance between the towers was decreased [1]
ii. The ship was a greater distance away from the towers [1]
iii. The signals had a longer wavelength [1]

Question 9

A compound microscope has an objective and eyepiece of focal lengths 0.40 cm and 3.0 cm respectively. The lenses are 4.9 cm apart. The sample to be studied is placed 0.5 cm from the objective.



If the sample forms an image(intermediate image) with the objective and that image formed, is now an object with respect to the eyepiece.

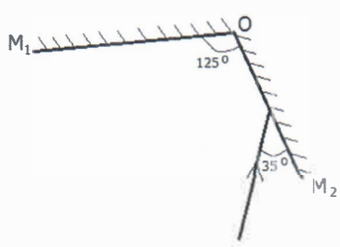
a) Calculate the **distance and position** of the intermediate image [3]

b) Calculate the **distance and position** of the final image [4]

c) Draw a ray diagram, showing the production of the final image [5]

Question 10

a) The figure shows two mirrors inclined to each other at an angle of 125°. A ray of light is incident on mirror M_2O at an angle of 35°. Calculate the angle through which the ray deviates from its original path. [3]



b) Fig 1 shows a scanner in which a laser beam is directed on to a rotating plain mirror. The mirror has a diameter of 25mm and the laser bean is offset from centre by 10mm. As the mirror rotates it intersects the beam which is reflected towards the target area.

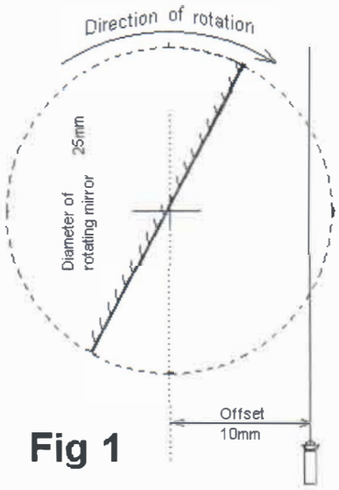


Fig 1

i. Draw a ray diagram showing how the reflected beam will sweep an arc across the target area. [2]

ii Calculate the angle of the arc through which the beam scans. [4]

iii. What should be the offset if the target area is to be limited to 70° [2]

iv. If the mirror rotates at a speed of 100RPM, what angular speed (in radians per second) does the beam sweep across the target area. [1]

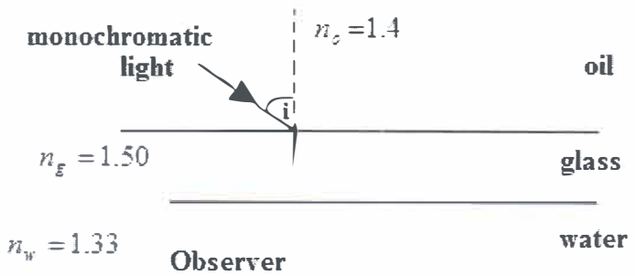
Question 11

A student conducting an experiment to verify the angle at which a ray of monochromatic light emerges through the water surface.

a) Draw the approximate path of the light, so that the observer can be positioned. Show all relative detail. [2]

b) To standardize the experiment the student started with an angle incidence(i) of 30°. At what angle of refraction should the student anticipate the emerging ray from the glass. [5]

c) As the angle of incidence increased, at some point the student noticed no light coming through the water. Why and at what angle of incidence [5]



Question 12

a) Show using suitable diagrams why a spherical mirror offers an advantage for use as a rear view mirror on vehicles. [2]

b) Vehicle headlamps usually have a reflecting mirror placed behind the lamp to produce an approximately parallel beam of light in front of the vehicle. Show by means of a suitable ray diagram where should the lamps be located relative to the reflecting mirror to produce the parallel beam of light. (assume a spherical mirror) [2]

c) A dentist wants a small mirror that, when positioned 24mm from a tooth, will produce a three and a half(3.5x) times upright image.

i. Draw a ray diagram showing how the image is produced. (Your ray diagram MUST show clearly what type of mirror should be used and where is the image located) [4]

ii. Calculate the focal length of the mirror? [4]

Formulae Sheet

Refraction, Reflection & Snell's Law

$$n_1 Sin\theta_1 = n_2 Sin\theta_2$$

$$n = \frac{1}{Sin\, C} \quad \text{at critical angle}$$

$$refractive\ Index = \frac{real\ \ depth}{apparent\ depth}$$

Young's double slit experiment (waves)

$$n\lambda = \frac{xd}{l}$$

$d\ Sin\ \theta = m\lambda$ Constructive interference

$d\ Sin\theta = (m+\frac{1}{2})\lambda$ Destructive interference

Hooke's Law, Vibration in strings and simple harmonics

$$F = -k\,x$$

$$v = \sqrt{\frac{T}{(\frac{m}{l})}}$$

$$PE_{\max} = \tfrac{1}{2}kA^2$$

$$KE_{\max} = \tfrac{1}{2}mv_0$$

$$v = \pm v_o\sqrt{1 \ - \ \frac{x^2}{A^2}}$$

$$v = \pm\omega_0\sqrt{A^2 - x^2}$$

$$v = A\omega$$

$$a = \frac{v^2}{A} \quad OR \quad a = \omega A^2$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$ Systems that follow Hook's Law

$$T = \frac{2\pi}{\omega}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$ Systems that are, or mimic pendulums

Vibrating system displacement in terms of time

$x = Sin\ \omega t$ or

$x = Cos\omega t$

Sound, Intensity & The Doppler Effect

Speed of sound in any material $v = \sqrt{\frac{B}{\rho}}$

Intensity = power/area

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

Loudness of sound in Decibel

$$dB = 10\log\frac{I_1}{I_2}$$

$$f' = \left(\frac{v}{v \pm v_s}\right)f_s$$ *Source leaving/ approaching stationary observer*

$$f' = \left(\frac{v \pm v_o}{v}\right)f_s$$ *Observer approaching /leaving stationary source*

Speed of light in free space

$c = 3\times10^8\ m/s$

Speed of sound in air

$v \approx (331+0.6T)m/s$

where T is the temperature in degrees Celsius