University of Ruhuna-Faculty of Technology

Bachelor of Engineering Technology

Level I (Semester II) Examination, Dec. 2017

Course Unit: ENT1253 Engineering Properties of Matter

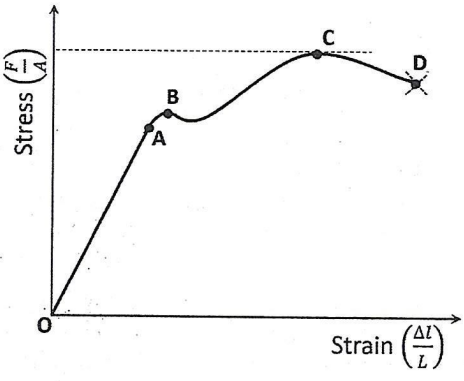
Time Allowed 3 hours

Answer all SIX(06) questions

All symbols have their usual meaning.

Acceleration due to gravity (g) is 9.8 ms^{-2}

1. Deformation of a solid under an applied longitudinal stress is depicted in the following figure.



Note:Use letters to represent regions.

(a) In the above figure, what are the elastic and plastic regions? Describe major physical differences observed between these two regions.

(b) Identify the *Yield Point*, *Fracture Point* and *Ultimate Tensile Strength* on the above figure. Briefly describe their significances.

(c) A carbon steel rod with square cross section is used to lift a vehicle weight 5000 kg. The rod is 10 mm thick and 3 m long. Calculate the elongation of the rod. (Modulus of Elasticity of Carbon Steel is 203 GPa.)

(d) (i) What is the Shear Modulus?

(ii) The edge of an Aluminum cube is 12 cm length. One face of the cube is firmly fixed to a vertical wall. A mass of 150 kg is then attached to the opposite face of the cube. What is the vertical deflection of this face? (The Shear modulus of Aluminium is 25 GPa.)

CONTINUED

2. Sound waves are vibrations traveling in a medium. Depending on the frequency of vibration sound waves can be divided in to three categories: Audible, Infrasonic and Ultrasonic.

(a) Briefly explain above three categories of sound waves with their frequency ranges and applications.

(b) A nuclear bomb is tested in a concrete compound of 10 m thick situated in a desert. A military observation camp is situated about 2 km away from the surface of the compound.

(i) How long does it take the sound of the explosion to reach the military camp. The air temperature in the desert is 40°C. (Modulus of Elasticity of concrete is 17 GPa and Density of concrete is 2400 kg/m^3)

(ii) Due to the above explosion air temperature within 500 m radius from the surface of the compound is raised by 10°C. Would the second explosion in the compound take longer or shorter time to reach the military camp compared to the first explosion?

(iii) Calculate the time required for the sound of the second explosion to reach the camp.

(c) The intensity of the sound created by the above explosion is measured to be 200 dB at the military camp. What is the intensity of the sound near the wall of the concrete compound?

3. (a) (i) The pressure of a gas container was measured as 539 torr. Convert this value into atmospheric pressure units(atm).

(ii) A gas in a container with 25.2 liters is at 25°C. Then the gas has been transferred into another container with 12.2 liters, which shows a 1500 torr of pressure at 25°C. What was the pressure of the original sample, in atmospheric pressure units?

(b) In a car lift, compressed air exerts a force on a piston with a radius of 10 cm. This pressure is transmitted to a second piston with a radius of 20 cm.

(i) How large a force must the compressed air exert to lift a 1.55×10^3 kg car?

(ii) What pressure is produced by this force? Neglect the weight of the pistons.

(c) Water is flowing in a fire hose with a velocity of 2.0 m/s and a pressure of 0.2 MPa. At the nozzle the pressure decreases to atmospheric pressure (101300 Pa.) There is no change in height. Calculate the velocity of the water exiting the nozzle. (Hint: The density of water is 1000 kgm^{-3})

4. Heat can be transferred from one place to another by either conduction, convection, radiation or a combine of the three.

(a) Show that the energy transfer (dQ) in a time interval (dt), from hotter surface to a colder surface in a solid, is proportional to the temperature difference.

(b) Consider a metal rod which has 4.0 J/s of heat flow between its two ends when one end is maintained at temperatures 100°C while the other end maintained at 110°C. What will be the rate of heat flow if the ends will be maintained at temperatures 200°C and 210°C.

(c) A block of ice at 0°C was kept on the upper surface of a metal slab. The slab has a of area of 0.36 m^2 and thickness 0.1 m. The lower surface is exposed to the steam at 100°C. After one hour 4800 g of ice has melted. Calculate the thermal conductivity of the material made of the slab.

(d) Wire fences are used in farms to keep the cows safe. A farmer stringed a wire fence in the middle of the day. He made it nice and tight so that his cows cannot push through it. That night all the wires were broken. How did the wires break?

5. The rate at which an object radiates energy (P), is proportional to the fourth power of its absolute temperature. This behaviour is expressed in an equation form known as Stefan Boltzmann law.

(a) State the Stefan Boltzmann law, introducing all the terms.

(b) The Sun is considered to be a perfect radiator with a power radiation of 4.2×10^{27} W. The radius of the Sun is 696,000 km. Determine the surface temperature of the Sun. (Stefan Boltzmann constant is 5.67×10^{-8} W/m^2 K^4.)

(c) If the temperature of the Sun were to increase from T to $2T$ and its radius from R to $2R$, then what is the ratio of the radiant energy received on earth, to what it was previously.

(d) A scientist has a system in space that is generating a lot of waste heat which he needs to get rid of by radiation into deep, cold space. His external radiator has a surface area of $1.0m \times 2.0m$ and has useful emission from only one side. The power he needs to dump is 1.0×10^3 W. What is the equilibrium temperature of his radiator in Celsius degrees? (Assume the emissivity of the radiator is 0.99).

CONTINUED

6. (a) As light travels from one medium to another, its frequency does not change but its wavelength does.

(i) Obtain a relationship between index of refraction and wavelength as light travels from medium 1 to medium 2.

(ii) A light ray traveling through air is incident on a smooth, flat slab of glass (with index of refraction 1.52) at an angle of 30^0 to the normal.

A. Find the angle of refraction.

B. Find the speed of light once it enters the glass.

C. What is the wavelength of this light in the glass? The wavelength of the incident light ray is 589 nm.

(b) Light of wavelength comparable to or larger than the width of a slit spreads out in all forward directions upon passing through a single slit. This phenomenon is called diffraction. A student is doing an experiment with a light of wavelength 580 nm, to study single slit diffraction patterns. He keeps the screen 2.00 m away from the slit and the width of the slit is 0.300 mm.

(i) Find the positions of the first dark fringes.

(ii) Find the width of the central bright fringe.

(iii) If the slit width is increased to the magnitude of 3.00 mm, what happens to the diffraction pattern. Explain briefly.