



MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: 25/4/2019

TIME: 8.30-10.30 AM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

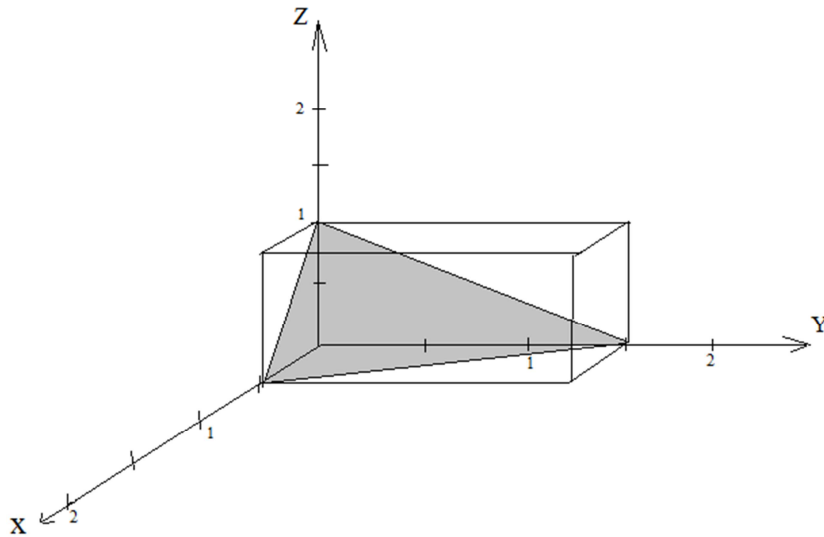
The following constants may be useful:

Density of steel, glycerine, air, mercury and blood are 7.7 g/cm^3 , 1.26 g/cm^3 , 0.001225 g/cm^3 , 13.6 g/cm^3 and 1.050 g/cm^3 respectively. Gravitation acceleration 9.8 m/s^2 . Surface tension of water 0.073 N/M , coefficient of thermal conductivity of glass $1.1 \text{ Wm}^{-1}\text{K}^{-1}$, Reynold number of blood flowing in a human artery $N_R=3000$, viscosity of blood $2.7 \times 10^{-3} \text{ N.s m}^{-2}$, viscosity of air $1.8 \times 10^{-3} \text{ N.s m}^{-2}$

SECTION A

QUESTION ONE (30 MARKS)

- a) In crystals, the axis of symmetry can only be two, three, four or six fold and not 5 or 7 fold. Give a reason why this is so (2 marks)
- b) The shaded plane represent a face of a crystal, identify the miller indices of the crystal (4 marks)



- c) Distinguish between an ionic and a covalent crystal (2 marks)
- d) Derive Bragg's law (2 marks)
- e) X-rays with a wavelength of 0.12 nm undergo first order diffraction from a crystal at 68° angle of incidence. Calculate the angle at which third order diffraction will occur? (6 marks)
- f) Explain how Bernoulli's equation adjusts if a flowing fluid in a pipe
- Slows down
 - Is horizontal (4 marks)
- g) An alien spherical body falls through still air in the earth's atmosphere with a velocity of 0.5 m/s. The body experiences viscous force of 700 N. Calculate the radius of the body. (6 marks)
- h) Define Madelung constant (2 marks)
- i) Define the term thermal conduction (2 marks)

SECTION B

QUESTION TWO (20 MARKS)

- a) Draw a hexagonal (rhombic) crystal in 2-Dimension (2 marks)
- b) Calculate Madelung constant for sodium chloride (6 marks)
- c) Consider rate of flow of heat (J/s) in a thin disc of some material of cross sectional area A and thickness δx . Suppose that the hotter section is at a temperature θ and that the colder section is maintained at $\theta - \delta\theta$. Derive an expression for coefficient of thermal conductivity of the material. (6 marks)
- d) A glass slab of a thermal insulator with a cross-sectional area of 100cm^2 is 3.00 cm thick. If the temperature of the hotter side is 300°C and that of the cooler side is 8°C , calculate amount of heat that flows through the slab in 1 day? (6 marks)

QUESTION THREE (20 MARKS)

- a) At one point in a pipeline, the water's speed is 3.00 m/s and the gauge pressure is $4.0 \times 10^4 \text{ pa}$. Find the gauge pressure at a second point in the line 11.0 m lower than the first if the pipe diameter at the second point is twice that at the first. (8 marks)
- b) Describe an experiment you can perform to determine coefficient of viscosity η using Stoke's law (6 marks)
- c) Calculate the terminal velocity of a steel ball bearing 2.00 mm in diameter falling in a glycerine of viscosity 0.150 N.s/m^2 (6 marks)

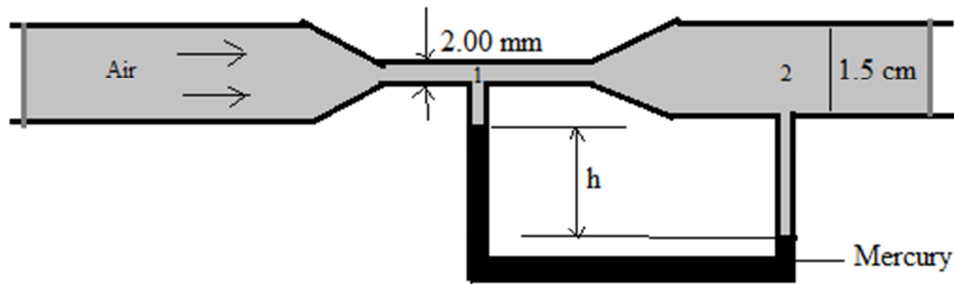
QUESTION FOUR (20 MARKS)

- a) Show that

$$V_2 = \sqrt{\frac{2(\Delta P)}{\rho(1 - A_2^2/A_1^2)}}$$

where ρ is density of air and other symbols hold their usual meaning. (6 marks)

- b) The horizontal circular pipe shown in Figure 1 has a constriction at point 1, of diameter 2.00 mm and a wider section at point 2, of diameter 1.5 cm. If the flow speed of air at the constriction is $9.20 \times 10^4 \text{ m/s}$, calculate the
 - i. pressure difference $\Delta P = P_2 - P_1$ between point 1 and 2 (6 marks)
 - ii. the difference in height h between the mercury columns in the u-tube (3 marks)



- c) In an experiment to study blood circulation in a human artery, it was noted that, flow turned turbulent at a speed of 38.5 m/s. Calculate the radius of the artery. (5 marks)

QUESTION FIVE (20 MARKS)

- a) Derive Poiseuille's formula using dimensional analysis (6 marks)
- b) A fatally wounded patient in a hospital receives IV blood transfusion through a needle of 0.30 mm and length 3 cm. If the required rate of flow is $6.0 \times 10^{-8} \text{ m}^3/\text{s}$, how high above the patient, the bottle supplying blood should be placed? (Ignore atmospheric pressure) (7 marks)
- c) Suppose God was to create a nano-millipede that could walk on water and which had 1000 legs, each of 1.5 nm in radius. Calculate the greatest possible mass this millipede could possess. (7 marks)