



# MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)  
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF  
EDUCATION (SCIENCE)

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: 8/8/ 2016

TIME: 8.30 – 10. 30 AM

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## INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**

The following constants may be useful, viscosity of water and glycerin are  $1.0 \times 10^{-3} \text{ N.s/m}^2$  and  $1500 \times 10^{-3} \text{ N.s/m}^2$  respectively, density of water is  $1 \text{ g/cm}^3$ , 1 atmospheric pressure =  $1.01 \times 10^5 \text{ N/m}^2$ , Density of glycerin  $1.26 \times 10^3 \text{ kg/m}^3$ , gravitational acceleration  $g = 9.8 \text{ m/s}^2$ .

## SECTION 1

### QUESTION ONE.

- a) Derive Bragg's law (4 marks)
- b) X-rays with a wavelength of 0.12 nm undergo first order diffraction from a crystal at  $68^\circ$  angle of incidence. What is the angle of second order diffraction? (6 marks)
- c) A spherical body of diameter 2 cm falls through glycerin with a velocity of 0.02 m/s. Calculate the viscous drag on the body due to the liquid. (4 marks)
- d) i) Derive the heat equation (4 marks)

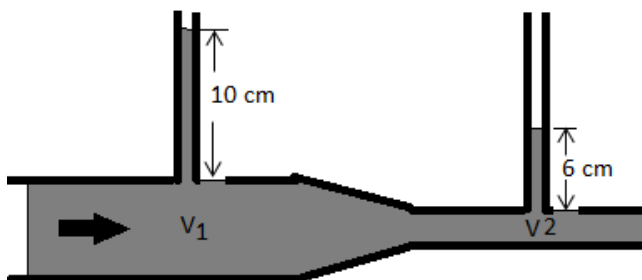
- ii) Hence show that the SI units of the coefficient of thermal conductivity are  
 $Wm^{-1}s^{-1}$  (2 marks)
- e) Find the heat energy transferred in 1 hour by conduction through a concrete wall of 1.5 m high 3.25 m long and 0.30 m thick if one side of the wall is held at 32 °C and the other at 6 °C. (4 marks)
- f) Liquid drops tend to take spherical shape, give a reason why this is so. (2 marks)
- g) Explain the origin of surface tension on surface of liquids (4 marks)

**QUESTION TWO.**

- a) Derive Bernoulli's equation using dimensional analysis. (8 marks)
- b) Explain how Bernoulli's equation adjusts if
- i) The tube is horizontal (2 marks)
  - ii) Speed of fluid increases (2 marks)
- c) Water is pumped from a borehole whose elevation is 564 m to a tank in a school compound at an whose elevation of 2096 m. The radius of the pipe at the inlet is 4 cm while pressure is 400 kPa. At the exit the radius of the pipe is 2 cm, Calculate the pressure at the exit (8 marks)

**QUESTION THREE.**

- a) i) Derive an expression for the coefficient of viscosity ( $\eta$ ) (4 marks)
- ii) Hence show that the SI units of coefficient of viscosity ( $\eta$ ) are  $kgm^{-1}s^{-1}$  (2 marks)
- b) The inside diameter of the wider section of the tube shown in figure 1 is 2.5 cm while diameter at the constriction is 1.5 cm.



**Figure 1**

- i) Show that (7 marks)

$$V_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho(1 - A_2^2/A_1^2)}}$$

- ii) Hence calculate velocity  $V_2$  (5 marks)

#### QUESTION FOUR.

- a) Consider a rectangular ring whose length is thrice its width and  $F$  is the force of surface tension acting on it due to water. Derive an expression for the surface tension ( $\gamma$ ) acting on the ring. (4 marks)
- b) Derive the SI units of surface tension ( $\gamma$ ) (2 marks)
- c) Jesus walked on the surface of water according to the bible. Assume his mass was 70 kg and the perimeter of his shoe was 32 cm. Also assume that he stepped with one foot at a time.
- i) If the angle between the surface tension force  $F$  and the normal to the surface is  $\theta$ . Show with a diagram the force  $F$  and the angle  $\theta$ . (2 marks)
- ii) Calculate the magnitude of the angle  $\theta$  (10 marks)
- ii) Explain why this might have violated the laws of physics (2 marks)

#### QUESTION FIVE.

- a) Derive the expression for Poiseuille's law (6 marks)
- b) A pipe carrying water from a tank 20 m high traverses  $3.0 \times 10^2$  m of wilderness to reach a remote town. If the radius of the pipe is 4 cm, calculate the volume flow rate. (6 marks)
- c) A spherical body of density  $2 \text{ g/cm}^3$  and diameter 1.0 cm falls through a vertical tube containing glycerin from a point A to a point B 1.5 m apart. Calculate
- i) Upthrust force acting on the body (2 marks)
- ii) Weight of the body (2 marks)
- iii) Time taken by the body to move from point A to B. (4 marks)