Department of Physics
CAT I
SPH2304: Analogue Electronics

1. For the circuit shown in Fig. 1, find :

   (i) the output voltage (2 marks)

   (ii) the voltage drop across series resistance (2 marks)

   (iii) the current through zener diode. (2 marks)

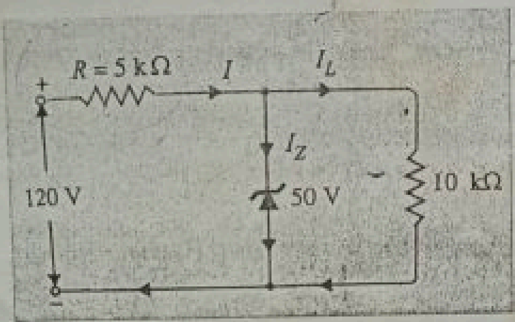
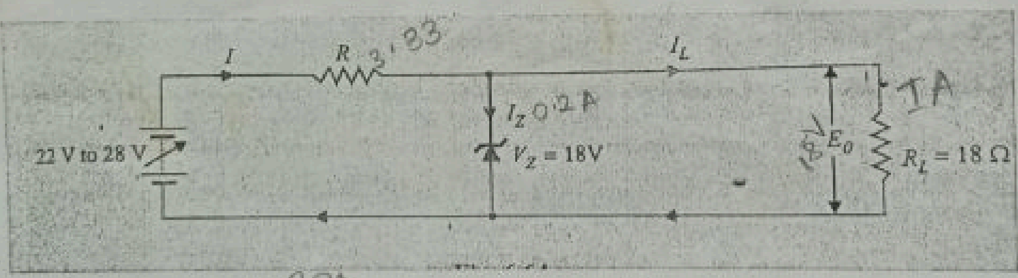


Fig. 1

2. The zener diode shown in Fig. 2 has $V_Z = 18$ V. The voltage across the load stays at 18 V as long as I_Z is maintained between 200 mA and 2 A. Find the value of series resistance R so that E_0 remains 18 V while input voltage E_i is free to vary between 22 V to 28V. (4 marks)



1.20A

Fig. 2

$$\frac{E_0 - V_Z}{I}$$

SPH 2201

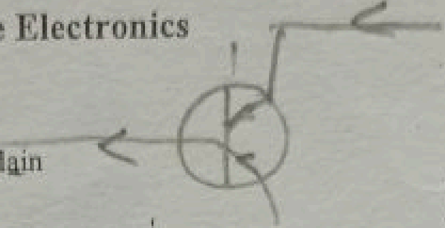
ENGINEERING DRAWING AND DE...

Jomo Kenyatta University of Agriculture and Technology (JKUAT)

Department of Physics

SPH 2233: Analogue Electronics

CAT II



Question One

(a). With the help of a circuit diagram of a pnp transistor explain

i. Biasing of a transistor (4 marks)

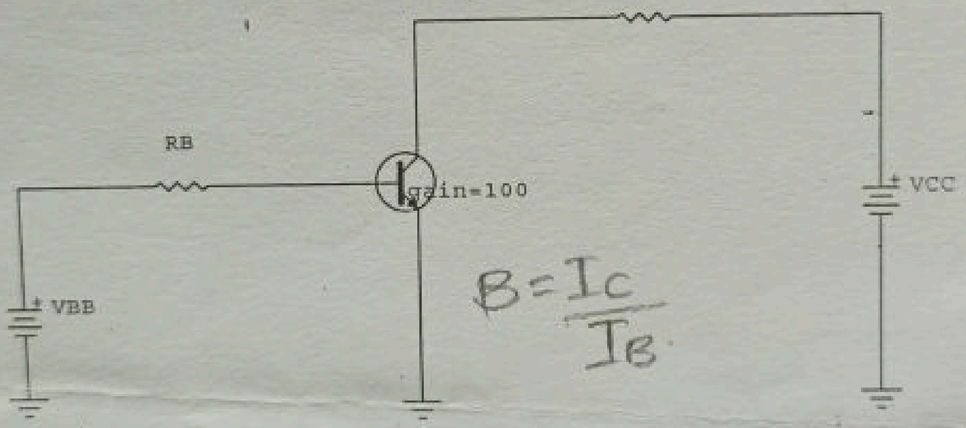
ii. Working of a transistor. (4 marks)

(b). Using Figure 1

i. $V_{BB} = 10V$ and $R_B = 100K\Omega$. What is the base current? (2 marks)

ii. What is the collector-emitter voltage if the collector current is 1mA, the collector resistance is 3.6KΩ, and the collector supply voltage is 10V? (4 marks)

VCE $I_C = 1mA$ $R_C =$



$B = \frac{I_C}{I_B}$

Figure 1

(c). What is the collector-emitter voltage in Figure 2? Use the second approximation. $= 0.7$ (6 marks)

0.7

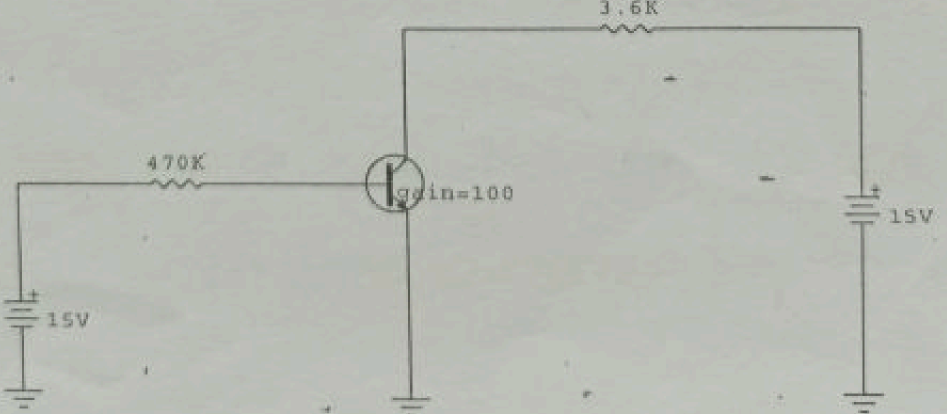


Figure 2

$b = I_C$ $V_{CC} - I_C R_C - V_{CE} = 0$

W1-2-60-1-6

JOMO KENYATTA UNIVERSITY

OF

AGRICULTURE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS 2022/2023

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN CONTROL AND INSTRUMENTATION

SPH 2233: ANALOGUE ELECTRONICS

DATE: APRIL 2023 **TIME: 2 HOURS**

INSTRUCTIONS

Answer **Question One** and ANY other TWO questions
Time: 2 Hours

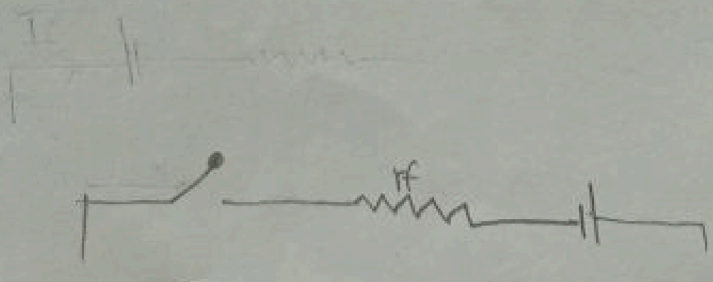
Question 1

a) Draw the equivalent circuit of a semiconductor diode (2 marks)

b) Discuss the importance of peak inverse voltage in rectification process. (3 marks)

c) A 10–V, Zener diode is to be used to regulate the voltage across a variable load resistance. Figure 1. The input voltage varies between 13V and 16V and the load current varies between 10mA and 85mA. The minimum Zener current is 15mA. Calculate the value of series resistance R. (6marks)

switch, rfo



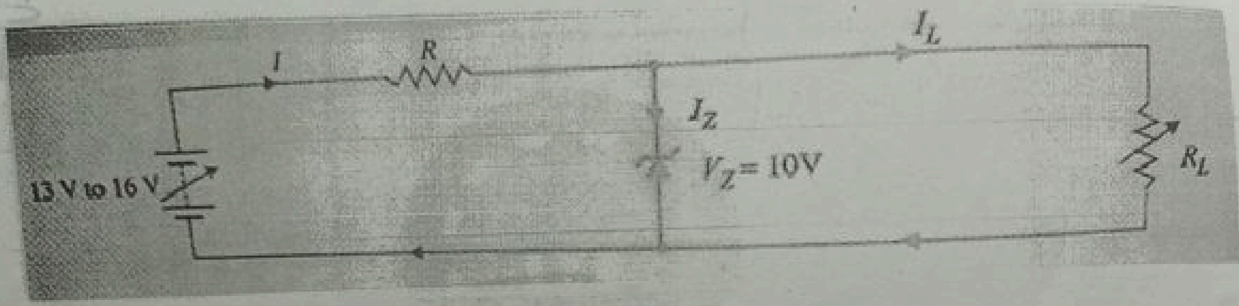


Figure 1

d) Find the voltage V_A in the circuit shown in Figure 2? (4 marks)

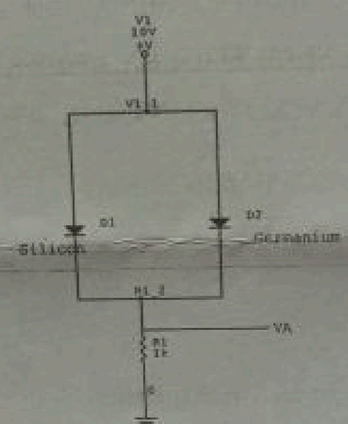


Figure 2

e) Determine if the diode (Ideal) in Figure 3 is forward biased or reverse biased? (5 marks)

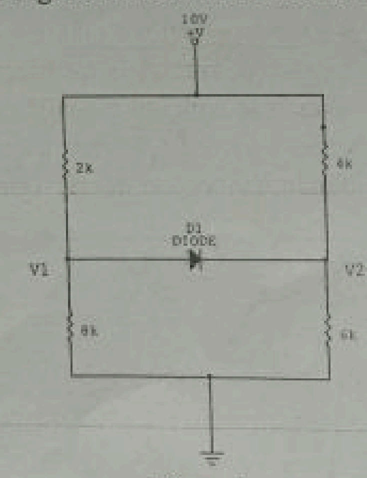
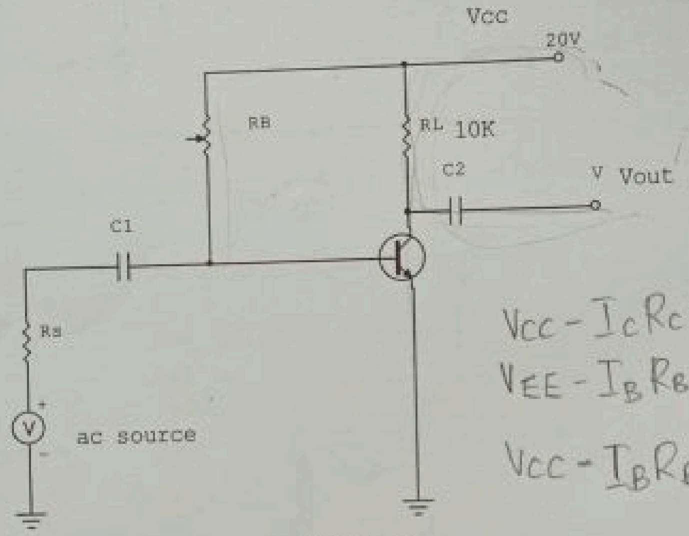


Figure 3

f) State the differences between JFET and Bipolar transistor. (4 marks)

g) Determine the value of R_B required to adjust the circuit of Figure 4 to optimum operating point. Take $\beta = 50$ and $V_{BE} = 0.7V$. (6 marks)



I_L

$V = I_L R_L$

$V - I_L R_L = 0$

$V_{CC} - I_C R_C - V_{CE} = 0$ $V = I_L R_L$

$V_{EE} - I_B R_B - V_{BE} = 0$

$V_{CC} - I_B R_B - V_{BE} = 0$

0.7

Figure 4

Question 2

a) Figure 5 show the centre – tap and bridge type circuits having the same load resistance and transformer turn ratio. The primary of each is connected to 230V, 50Hz supply.

i. Find the d.c. voltage in each case. (6 marks)

ii. PIV for each case for the same d.c. output. Assume the diodes to be ideal. (4 marks)

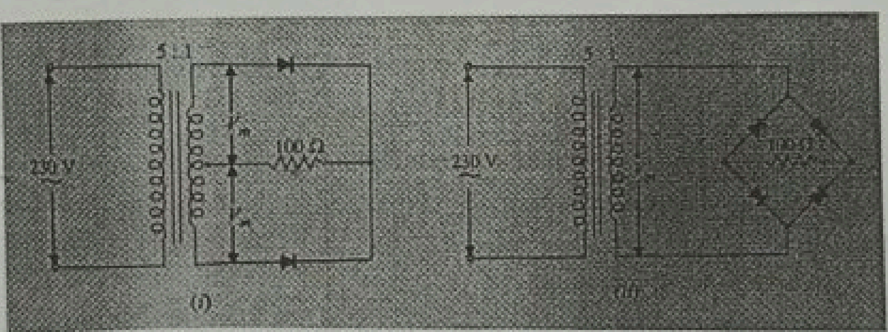


Figure 5

b) For the simple parallel clipper of Figure 6 below, find the shape of the output voltage V_o across the diode if the input is a sine wave signal of peak voltage 30V. What will happen when diode and resistor are inter- changed? (6 marks)

c) What would be the values of V_C, V_E and V_{CE} for the circuit in Figure 7 below?(4 marks)

Figure 8

c) If the zener diode is disconnected in Figure 8, what is the load voltage? (2 marks)

d) Assume a supply voltage of Figure 8 decreases from 20 to 0 V. At some point along the way, the zener diode will stop regulating. Find the supply voltage where regulation is lost. (2 marks)

e) Calculate current through 330Ω, zener diode and 1.5KΩ in Figure 8 (6 marks).

Question Four

a) In the circuit of Figure 9, what value of R_L causes $V_{CB} = 5V$? (6 marks)

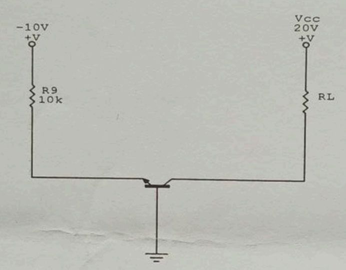


Figure 9

b) Find out whether the transistor of Figure 9 is working in saturation or well into saturation. Use first approximation and all resistor values are in MΩ. Gain is 100. (6 marks)

c) Draw the schematic symbol of an operational amplifier indicating the various terminals. (4 marks)

d) Given the OP-amp configuration in Figure 10, determine the value of R_f required to produce closed-loop voltage gain of -100. (4 marks)

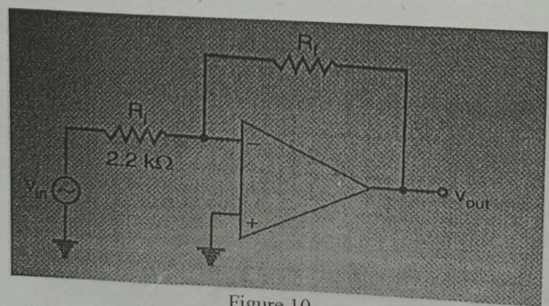


Figure 10.

~~ECT 210:~~ ENNGINEERING DRAWING AND DESIGN 1

SPH 2206

CAT 2

DUE; 14th February, 2023

LECTURER: Eng. Ojwang Charity

2'5

Q1. A point P is 5mm outside a 50mm diameter circle. If the circle roles for one complete revolution along a fixed horizontal line, draw the locus of point P (a superior trochoid).

0'25

P is to start from the bottom position as illustrated below.

a. Show the location of point P on your drawing ½ mark

60

b. Show subdivision of rotating circle and respective numbering 1 mark

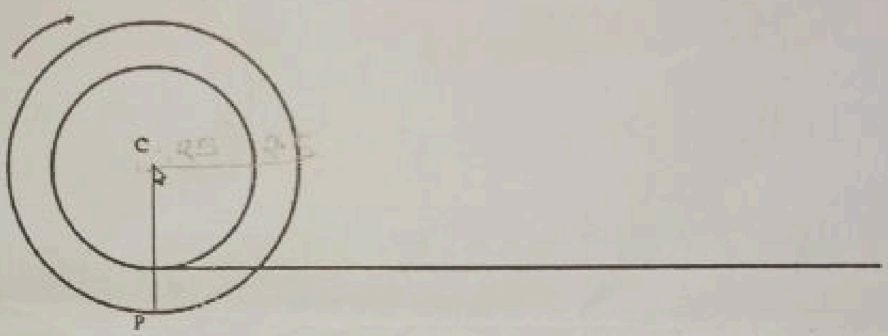
c. Show horizontal projections of all points on rotating circle 1 mark

d. Show vertical projection of each center line on line AB 1 mark

e. Show correct numbering of each center line on line AB 1 marks

f. Using French curves draw the locus of point p after one revolution 10 marks

g. Draw the circumference of the rotating circle ½ mark



Q2.

a. Draw a parabola of base 120mm and height 60mm by tangent method. 10 marks

b. Draw and show the Directrix and Focus on your drawing ½ mark

c. Label point P. ½ mark

d. Draw a tangent and normal at any point on the curve 4 marks

Q1. COMPULSORY 30 MARKS

Draw first angle orthographic projection of the figure below using a meter line and an appropriate scale.

a. A front view as seen from direction A 5 marks

b. An end view as seen from side B, and 6 marks

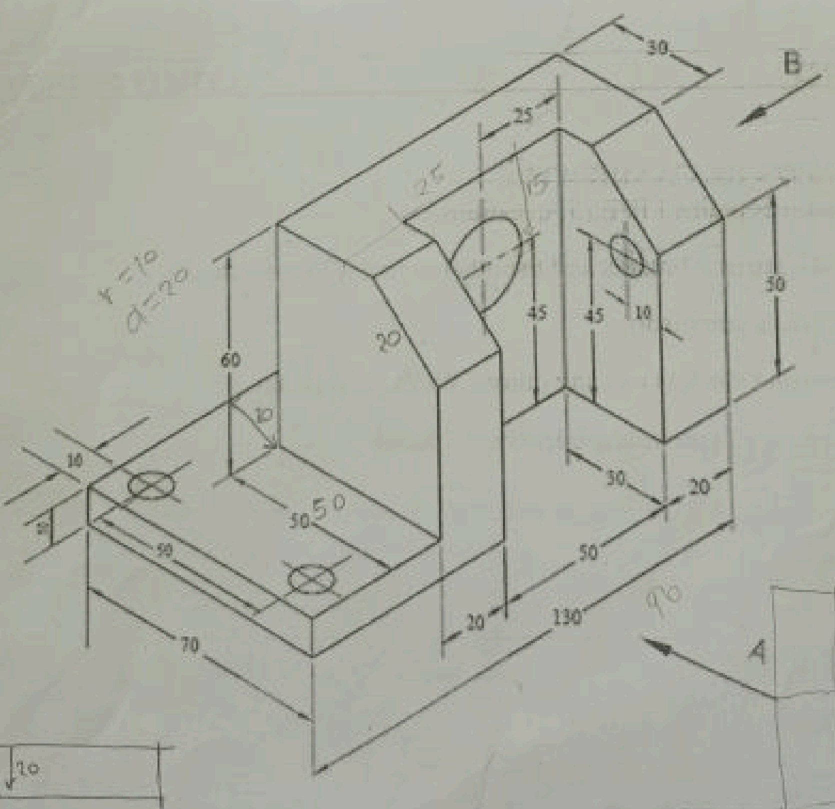
c. A top view 5 marks

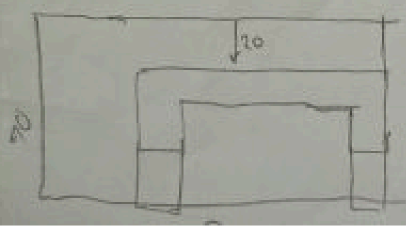
d. Draw border lines on your drawing paper 2 marks

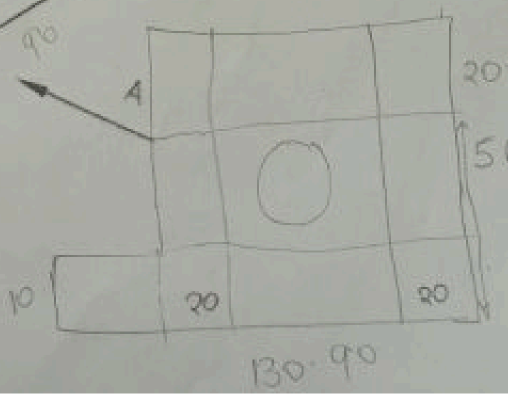
e. Insert a Title Block, 5 marks

f. Draw first angle projection symbol 2 marks

g. Insert leading dimensions 5 marks







Q2. 20 MARKS

a. Draw an INVOLUTE of a Hexagon of sides 25mm 10 marks

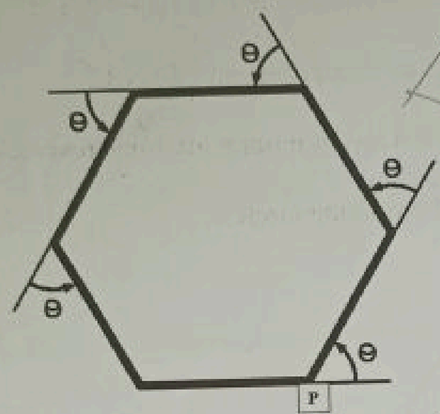
b. Show the value of Θ. 2 marks

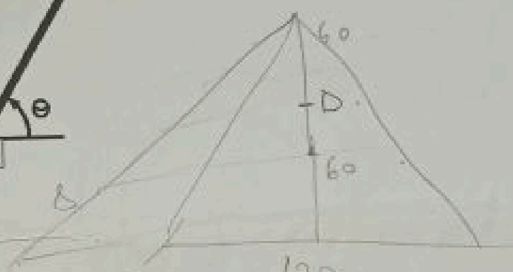
c. Show the location of P_1, P_2, P3, P4, P5 and P6 on the curve 3 marks

d. Draw and show the normal and tangent to the curve 5 marks

8 points 15

30.3
27⌐40.5





Q3. 20 MARKS parabola e>1

a. Draw a parabola of base 120mm and height 60mm by tangent method. 10 marks

b. Draw and show the Directrix on your drawing 2 marks

c. Draw and show the focus on your drawing 2 marks

d. Label point P. 1 mark

e. Draw a tangent and normal at any point on the curve 5 marks

Q4. 20 MARKS

A point P is 5mm outside a 50mm diameter circle. If the circle roles for one complete revolution along a fixed horizontal line, draw the locus of point P (a superior trochoid). P is to start from the bottom position as illustrated below.

R=25

1cm = 50mm
50mm

25+5=30.

a. Show the location of point P on your drawing 1 marks

b. Show subdivision of rotating circle and respective numbering 2 marks

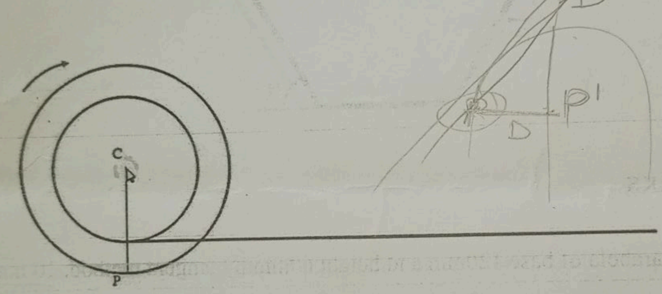
c. Show horizontal projections of all points on rotating circle 2 marks

d. Show vertical projection of each center line on line AB 1 mark

e. Show correct numbering of each center line on line AB 1 marks

f. Using French curves draw the locus of point p after one revolution 12 marks

g. Draw the circumference of the rotating circle 1 marks



Q5. 20 MARKS

A CAM drives a FLAT RECIPROCATING FOLLOWER in the following manner:

During first 120° rotation of the cam, follower moves outwards through a distance of 20 mm with SIMPLE HARMONIC MOTION. The follower dwells during next 30° of cam rotation.

During the next 120° of cam rotation, the follower moves inwards with simple harmonic motion.

The follower dwells for the next 90° of cam rotation.

The minimum radius of the cam is 25 mm. Draw the profile of the cam.

SMA 2304: ORDINARY DIFFERENTIAL EQUATION I, CAT ONE, TIME: 1 HOUR

a) Define and give an example to

i. Ordinary differential equation [1 Marks]

ii. Partial differential equation [1 Marks]

b) State the order and the degree of the differential equation

$$3\frac{d^3y}{dx^3}+\left(\frac{d^2y}{dx^2}\right)^3+4\left(\frac{dy}{dx}\right)^5+y=e^{2x}$$ [2 Marks]

c) Obtain the differential equation associated with the primitive

$$y=C_1e^{-3x}+C_2e^{x}+C_3e^{-x}$$ [3 Marks]

d) Show that the equation

i. $(6xy+2y^2-5)dx+(3x^2+4xy-6)dy=0$ is exact [1 Marks]

ii. Hence solve the equation in (i) above [3 Marks]

e) Solve the following differential equations

i. $xydx+(1+x^2)dy=0$ [3 Marks]

ii. $\frac{dy}{dx}+\frac{y}{x}=e^x$ [3 Marks]

f) Show that the following equation is said to be homogeneous degree n. Then find n and determine the solution to $\left(y+\sqrt{x^2-y^2}\right)dx-xdy=0$ [4 Marks]

g) Use the method of variation of parameters to solve differential equation

$$\frac{d^2y}{dx^2}+6\frac{dy}{dx}+9y=\frac{e^{-3x}}{x^3}$$ [5 Marks]

h) Determine the solution to $\frac{dy}{dx}+y=xy^3$ [4 Marks]

Instructions: Answer Question ONE and any other TWO Questions.

QUESTION ONE {30 Marks}

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

SMA 2304: ORDINARY DIFFERENTIAL EQUATION I CAT TWO

TIME: ONE HOUR

a) Explain each of the following as they are used in ordinary differential equations

(i) Ordinary point [1 Marks]

(ii) Regular singular point [1 Marks]

Hence determine a series solution in powers of x for the differential equation

$$x^2\frac{d^2y}{dx^2} + (x^2 + x)\frac{dy}{dx} + (x-9)y = 0$$

[8 Marks]

b) Determine the general solution of the equation $\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = 4e^{3x}$ [2 Marks]

c) Using a method of undetermined coefficient find the particular solution of differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + 2y = 3e^x Cos(2x)$ given that when $x = 0, y = 2$ and $\frac{dy}{dx} = 3$ [5 Marks]

d) Given the following systems $\begin{cases} 2\frac{dx}{dt} + 3\frac{dy}{dt} - 2x + y = t^2 \\ \frac{dx}{dt} - \frac{dy}{dt} + 3x + 4y = e^t \end{cases}$ express x as a function of t [8 Marks]

e) Using Taylor's series expansion method determine a power series solution of the initial value problem $(x^2-1)\frac{d^2y}{dx^2} + 3x\frac{dy}{dx} + xy = 0$ given $y(0) = 3, y'(0) = -4$ [5 Ma

TWO Questions.

$= -2x - 0.5\, e^{-0.5t}$

$e^{0.5t}$

$C \quad -2e^{-0.5t} + C$

$-2e$

$e^{-2e^{-0.5t}}, \ e^{-0.5t}$

$-2e^{-0.5t} + -0.5t$

W1-2-60-1-6

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS 2022/2023

YEAR III SEMESTER I EXAMINATION FOR THE DEGREES OF BACHELOR OF SCIENCE CONTROL AND ISTRUMENTATION, GEOPHYSICS AND RENEWABLE ENERGY.

SMA 2304: ORDINARY DIFFERENTIAL EQUATIONS I

DATE: April 2023 **TIME: 2 Hours**

Instructions: Answer Question ONE and any other TWO Questions.

QUESTION ONE {30 Marks}

a. Briefly explain the following;
   i) An ordinary differential equation [1 Mark]
   ii) The degree of a differential equation [1 Mark]

b. The number of individuals in JKUAT who have heard a rumor at time t is given by

$N(t) = Ce^{-2e^{-0.5t}}$ obtain a differential equation for the rate of propagation of the rumor. **[4 Marks]**

c. Show that the equation $\left(\frac{3-y}{x^2}\right)dx + \left(\frac{y^2-2x}{xy^2}\right)dy = 0$ is exact. Hence find $F(x,y)$ given that $F(-1,2) = 0$. **[6 Marks]**

d. Determine the solution to the differential equation $\frac{dy}{dx} + y = xy^4$. **[6 Marks]**

e. Obtain the general solution to $x^2\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2y = x^3$. **[6 Marks]**

f. Use Taylor series expansion to obtain the power series solution of
$(2x^2-3)y'' - 2xy' + y = 0 \qquad y(0) = 1 \quad and \quad y'(0) = 5$ **[6 Marks]**

$+y \times \frac{-3}{y^4} \qquad xy^4 \times \frac{-3}{y^4} \qquad -2e^{-0.5t} + -0.5t$

$-2e^{-0.5t} + e^{-0.5t}$

QUESTION TWO {20 Marks}

a. A company is trying to expose a new product to as many people as possible through television advertising. Suppose that the rate of exposure to the new people is proportional to the number of those who have not seen the product out of L possible viewers. No one was aware of the product at the start of the campaign and after 5 days 20% of L are aware of the product. Form a differential equation satisfied by the number N of people who will be aware of the product at any time t and state the condition N must satisfy. Hence determine what percentage of L will have been exposed after ten days of the campaign. **[10 Marks]**

b. Prove that the substitution $y = ux$ reduces the homogeneous equation of the first order $y' = f\left(\frac{y}{x}\right)$ to separable equation in u *and* x. Hence solve the equation

$(2xy + 3y^2)dx - (2xy + x^2)dy = 0 \quad y(1) = 2$, **[10 Marks]**

QUESTION THREE {20 Marks}

a. Use the method of variation of parameters to solve the differential equation

$\frac{d^2y}{dx^2} + y = \tan x$ **[10 Marks]**

b. Find the complete solution for the linear differential system

$\frac{dx}{dt} + \frac{dy}{dt} + 2x + 6y = 2e^t$,

$2\frac{dx}{dt} + 3\frac{dy}{dt} + 3x + 8y = 1$ **[10 Marks]**

QUESTION FOUR {20 Marks}

a. Determine the solution to the differential equation $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 3y = 3e^x + 2x$. **[8 Marks]**

b. Show that $x = 0$ is an ordinary point of the equation $(1-x^2)y'' - 6xy' - 4y = 0$ hence, find the power series solution of the equation. General **[12 Marks]**

$2 + 10e^t$

$-D^2y + Dy + 2y - 10e^t + 2 = 0$

$D - Fe^t$

$D^2y + Dy + 2y + 10e^t - 2 = 0$ $2D\,2e^t + 6e^t$

JKUAT

PHYSICS DEPARTMENT

SPH 2204: MEASUREMENTS AND INSTRUMENTATION II

CAT 1 **February 2023** **TIME: 1 HOUR**

Attempt QUESTION ONE and any other ONE question

QUESTION ONE

(a) (i) Explain the meaning of static characteristics of instruments.

(ii) Distinguish between the terms accuracy and precision as they refer to instrument performance characteristics and illustrate them on separate diagrams for systems exhibiting the following:

(I) low accuracy and high precision (II) low accuracy and low precision

(iii) Explain the phenomenon of hysteresis and state one possible cause of hysteresis in measurement systems. Draw a diagram showing hysteresis in instruments and on it indicate 'dead zone, 'maximum input hysteresis', and 'maximum output hysteresis'.

(b) (i) Derive the equations for the amplitude ratio of a first-order system when subjected to a sinusoidal input.

(ii) A first order system has a time constant of 0,2 s. Find the amplitude ratio and phase angle at a frequency of 1 Hz.

QUESTION TWO

(a) (i) Differentiate between passive and active transducers, giving an example of each.

(ii) With the aid of a diagram, explain the construction feature of working of LVDT.

(iii) Explain how to measure displacement using LVDT.

(b) (i) Use a diagram to explain the working of a thermocouple transducer

(ii) Describe, with the aid of a diagram, the method of measurement of temperature with thermocouple.

(iii) State one advantage and one disadvantage of a thermocouple transformer

QUESTION THREE

(a) (i) Use a diagram to explain the construction, principle of operation, working of resistance temperature detector (RTD).

(ii) A platinum RTD PT100 measures 100 Ω at 0 °C and 139.1 Ω at 100 °C. Calculate:

(I) the temperature coefficient of resistance of RTD PT100

(II) the resistance of the RTD at 180 °C.

(b) (i) Distinguish between transducers and inverse transducers and give an example of each.

(ii) Use a diagram to explain the part of a transducer and their functions.

(iii) Draw the response of a first-order instrument to a step input.

(iv) Find the time at which the ratio of the output to the input of a first-order instrument reaches 80 % if its time constant is 0.6 s.

$R = R_0(1 + \alpha \Delta T)$

JKUAT

PHYSICS DEPARTMENT

SPH 2204: MEASUREMENTS AND INSTRUMENTATION II

CAT 2 March 2023 **TIME: 1 HOUR**

Attempt QUESTION ONE and any other ONE question

QUESTION ONE

(a) (i) Define an optical amplifier and explain the need for such amplifiers in communication systems

(ii) Use a diagram to derive the expression for the voltage gain of an inverting OP AMP.

(iii) An inverting amplifier has a resistor $R_1 = 40\ k\Omega$ and $R_f = 100\ k\Omega$ and open-loop gain of 2×10^5, where the symbols have their usual meanings. Determine the closed-loop voltage gain.

(b) (i) Use a diagram to explain how a quarter bridge strain gauge is used to measure strain and derive the governing equation.

(ii) Define impedance matching and explain why it is important in measurement systems.

(iii) With the aid of a diagram, explain how impedance matching is achieved in an antenna with a television set.

(c) (i) With the aid of a suitable diagram, explain the working of an X-Y chart recorder.

(ii) Give two applications of X-Y chart recorders.

QUESTION TWO

(a) (i) With the aid of a clear diagram, describe working of an liquid crystal display (LCD) used as a display device.

(ii) Discuss any one advantage and one disadvantage of LCD displays.

(b) (i) What is signal conditioning and why is it required in measurement systems?

(ii) Draw the block diagram of an AC signal conditioning system. Explain the function of each block.

(c) (i) Explain the need for analogue-to-digital-converter (ADC) and digital-to-analogue (DAC) in a measurement system.

(ii) Use a diagram to discuss the construction and operation of any one type of DAC with a neat diagram.

(iii) Describe, with the aid of a clear diagram, how the turbine flow meter are used for measurement of fluid flow.

QUESTION THREE

(a) (i) Briefly explain what filters are and why they are needed in instrumentation systems.

(ii) Draw the diagram of a low-pass RC filter and explain its operation.

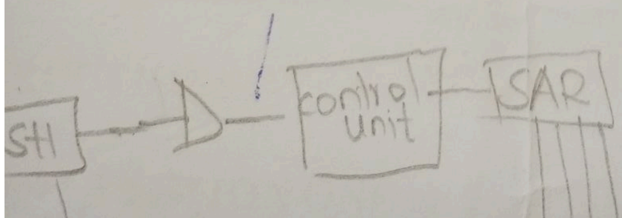
(iii) With the aid of a block diagram, to explain how a filter capacitor is used to block out AC signals and pass DC signals.

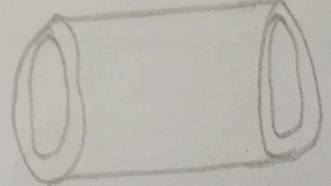
(b) (i) Use a clear a diagram to explain the operation of the strain gauge type torque meter.

(ii) State two advantages of the strain gauge torque meter.

(c) (i) Distinguish between positive and negative feedback in reference to feedback amplifiers

(ii) With the aid of a diagram, derive the expression for the voltage gain of a positive feedback amplifier





W1-2-60-1-6

JOMO KENYATTA UNIVERSITY

OF

AGRICULTURE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS 2022/2023

SECOND YEAR FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CONTROL AND INSTRUMENTATION

SPH 2204: MEASUREMENTS AND INSTRUMENTATION II

DATE: APRIL 2023 **TIME: 2 HOURS**

INSTRUCTIONS

Attempt QUESTION ONE and any other two questions. QUESTION ONE carries 30 marks and the rest carry 20 marks each

QUESTION ONE

(a) (i) Use a block diagram to explain the operation of an optical amplifier used in fiber optic communication systems. **(3 marks)**

(ii) Draw the diagram of a non-inverting amplifier and derive the expression for its voltage gain. **(3 marks)**

(b) (i) Distinguish between static and dynamic characteristics of instruments. **(2 marks)**

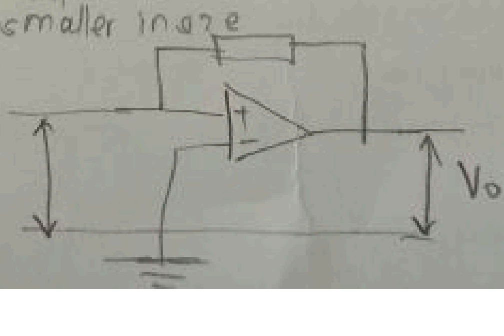
(ii) A first-order instrument has a time constant of $4.0 \times 10^{-4} s$. If a step input is applied, determine the time required to attain an amplitude ratio of 95% **(2 marks)**

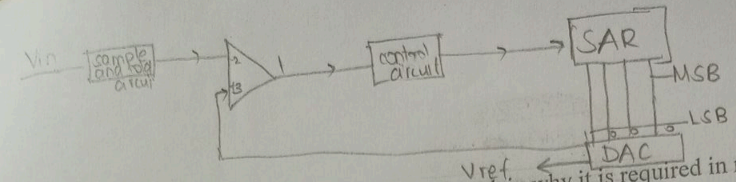
(c) (i) With the aid of a clear diagram, describe working of an light emitting diode (LED) as a display device. **(5 marks)**

(ii) Discuss any two advantages of LED display. **(2 marks)**

cheap
smaller in size

$$\frac{V_o}{V_i} = \left(\frac{R_f}{R_1} + 1\right)$$





(d) (i) Define signal conditioning and explain why it is required in measurement systems. **(2 marks)**

(ii) Draw a block diagram of the direct current (DC) signal conditioning system and explain the functions of the various blocks. **(4 marks)**

(e) (i) Distinguish between primary and secondary transducers and give an example of each. **(3marks)**

(ii) Use a diagram to explain the construction of a Bourdon tube and its use for measurement of pressure. **(4 marks)**

QUESTION TWO

(a) (i) Explain the terms fidelity and dynamic error as they refer to measurement systems: **(2 marks)**

true value

(ii) Derive the expression for the amplitude ratio of a second-order system subjected to a sinusoidal input signal. **(2 marks)**

$\frac{1}{\sqrt{(1-r^2)^2-(2\zeta r)^2}}$

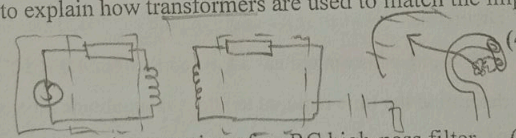
(iii) A second-order instrument has a natural frequency of 6 Hz and damping ratio of 0.4. Determine its amplitude ratio and the phase angle at a frequency of 4 Hz. **(3 marks)**

(b) (i) Explain what is meant by analogue to digital converter (ADC) and explain why it is an essential component of some required in measurement systems.**(2 marks)**

(ii) With the aid of a diagram, explain the working of the successive approximation ADC. **(5 marks)**

(c) (i) Define the term impedance matching and explain why it is needed in electronic systems. **(2 marks)**

(ii) Use a diagram to explain how transformers are used to match the impedance of circuits. **(4 marks)**



QUESTION THREE

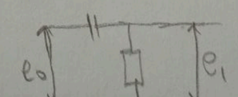
(a) (i) Use a diagram to explain the operation of an RC high-pass filter. **(4 marks)**

(ii) Use a block diagram to explain the operation of a filter capacitor to filter out dc signals and pass ac signals. **(3 marks)**

(b) (i) Use a diagram to explain the operation of a spring-mass accelerometer and derive the governing equation. **(4 marks)**

(ii) Determine the natural frequency and the maximum measurable acceleration of an

$$a_2\frac{d^2x_0}{dt^2}+a_1\frac{dx_0}{dt}+a_0x_0=bx_i$$



accelerometer that has a seismic mass of 50 g and a spring constant of 5000 N/m if the maximum mass displacement is +40 cm before the mass hits the stop. **(3 marks)**

(c) (i) Explain what is meant by a feedback amplifier. **(1 mark)**

(ii) Use a diagram to derive the expression for the voltage gain of a negative feedback amplifier. **(3 marks)**

(iii) Explain how the gain stability is achieved in negative feedback amplifier. **(2 marks)**

QUESTION FOUR

(a) (i) Use a diagram to discuss the direct method for magnetic tape recording used for instrumentation purposes. **(4 marks)**

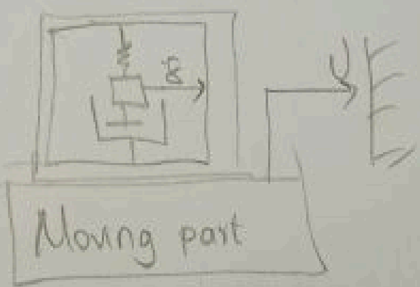
(ii) The resistance of a thermistor is 1020 Ω at 27 °C. Calculate the temperature when the thermistor resistance is 2100 Ω if the corresponding constant of the material is $\beta = 3140$. **(3 marks)**

(b) (i) Use a diagram to discuss the construction and operation of a piezoelectric transducer. **(4 marks)**

(ii) Derive the expression for output voltage in piezoelectric transducer. **(3 marks)**

(c) (i) Draw the diagram showing the construction of an electromagnetic flowmeter and explain its working. **(4 marks)**

(i) Explain one advantage and one disadvantage of electromagnetic flowmeters. **(2 marks)**



$\frac{A}{1+B} = \frac{V_o}{V_i}$

$V_o(1+B) = AV_i$

$V_o + BV_o = AV_i$

$V_o \times V_i = AV_i$

$V_i = BV_d$

$A = \frac{V_i}{V_o}$ $B = \frac{V_i}{V_d}$

$B = \frac{V_f}{V_i}$ V_f

$A = V_o - V_f$

$BV_i = V_f$

$A = V_o - BV_i$

$V_f = V_i - V_d$

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
CAT 1 for COIN & REEN – 15th Feb 2023
SCH 2203 NUCLEAR AND RADIOCHEMISTRY

USEFUL DATA:

1 MeV	$= 1.60 \times 10^{-13}$ J	m_p	$= 1.67265\times10^{-24}$ g
1 amu	$= 1.6605655\times10^{-24}$ g		
m_n	$= 1.67496\times10^{-24}$ g		
Avogadro's no.	$= 6.022 \times 10^{23}$ /mol		

a) Ernest Rutherford published his atomic theory and he based his theory on a model of the atom known as the nuclear atom. Describe three features based on his theory. **[4 mks]**

the nuclear particles
✓There are as many protons as there are many electrons in the nucleus

b) Define the following types of Stability: **[2 mks]**

i. Thermodynamic Stability (Binding Energy):

✓Different atoms have different number of protons

ii. Kinetic Stability:

c) With the help of suitable examples identify any five modes of radioactive decay **[10 mks]**

d) Nuclear stability depends on a number of factors discuss any two factors that may help in predicting mode of decay of a radioactive isotope even N= **[6 mks]**

e) Explain how the binding energy of a nucleus reflects its stability. **[2 mks]**

f) How much time will be required for a sample of H-3 to lose 75% of its radioactivity? The half-life of tritium is 12.26 years. **[3 mks]**

g) The half-life of plutonium-239 is 24,000 years. What percentage of nuclear energy waste generated in the year 2004 will be present in the year 2100? **[4 mks]**

h) How many α and β particles are emitted in passing down from $^{232}_{90}Th$ to $^{208}_{82}Pb$. **[4 mks]**

i) A bone taken from a garbage pile buried under a hill-side had 14C/12C ratio 0.477 times the ratio in a living plant or animal. What was the date when the animal was buried? The half-life of carbon-14 is 5730 years. **[5 mks]**

$\frac{232}{90} = \frac{228}{88} = \frac{224}{86} = \frac{220}{84} = \frac{216}{82} = \frac{212}{80}$ $\frac{208}{78}$ $\frac{208}{76}$

232

JOMO KEYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

CAT 2 – COIN and REEN – March 22, 2023

SCH 2203: NUCLEAR AND RADIOCHEMISTRY-MARKING SCHEME

a) Explain the following terms: (4 marks)

i. Nuclear fission

ii. Chain reaction

iii. Subcritical

iv. Supercritical

b) Describe the penetration power of alpha, beta and gamma radiation and their ionizing ability. (4 marks)

c) With help of examples, Differentiate between;

i) Natural versus artificial nuclear reactions (4 marks)

ii) Particle-particle versus spallation reaction. (4marks)

d) Ionising radiations damage to living system can be classified as either somatic or genetic. Explain these two types of damages. (3 Marks)

e) Complete the notations for the following nuclear processes by filling in what x is, write accompanying equations for each process. (4marks)

i) $^{130}Te(d\ ,2n)x$, $^{55}Mn(n\ ,\alpha\ )x$,

ii) $^{9}Be\ (\alpha, x)\ ^{12}C$.

f) State four main points that conclude the theory of disintegration. (4marks)

g) Two samples of equal quantity were introduced in a scintillation detector. One had a short half-life while the other had a high half-life. Which of this two will give a higher counting rate? Give a reason for this observation. (2 marks)

h) Discuss any three sources of radiations. (3 marks)

- natural
- cosmic rays
- human activity

i) A one kilogram ball of uranium-235 has critical mass, but the ball broken in small chunks does not. This is the phenomenon observed in a nuclear bomb, explain. (3 marks)

j) Describe how cobalt-60 is used to treat cancer. (3 Marks)

$39 + {}^{0}e \longrightarrow {}^{39}_{18}$

-3

-2

W1-2-60-1-6

JOMO KEYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS 2022/2023

YEAR TWO SEMISTER TWO FOR THE DEGREE OF BACHELOR OF SCIENCE, BACHELOR OF SCIENCE IN ANALYICATICAL CHEMISTRY, BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY AND BACHELOR OF SCIENCE IN BIOLOGICAL SCIENCES.

SCH 2203: NUCLEAR AND RADIOCHEMISTRY

DATE: APRIL 2023 TIME: 2HOURS

INSTRUCTIONS: Attempt question **ONE** and any other **TWO** questions from the given four. Question one carries thirty (30) marks and questions two to four carries twenty (20) marks each.

Question One: (Compulsory)

i) Mass of $^{7}_{3}Li, ^{6}_{3}Li$ *and* $^{1}_{0}n$ are 7.016. 6.0151 And 1.0087 amu respectively, calculate the binding energy of nucleon in $^{7}_{3}Li$, in MeV. (6marks)

ii) The average mass of chlorine is 35.5. The mass numbers of the two isotopes is 35 and 37. Give the proportion in which the two isotopes are present in ordinary chlorine. (6marks)

iii) By natural radioactivity, uranium-238 emits an alpha particle. The heavy residual daughter nuclear in turn emits a beta particle to give a stable heavy nucleus. By use of equation determine.
   a) The mass numbers of the daughter nuclides.
   b) The atomic numbers of the two nuclides and identify them. (5marks)

iv) If the actual masses of hydrogen and neutron are 1.0072765 amu and 1.008665 amu, why then do the designations $^{1}_{1}H$ *and* $^{1}_{0}n$ show the same mass number? (3marks)

v) Differentiate between ionizing and non-ionizing radiation. (5 marks)

vi) What are the three common types of radiations resulting from spontaneous radioactivity? (5 marks)

$^{7}_{3}$(protons + neutrons)

7 < 3p + 4n

Question Two:

i) Nuclear reactions can be classified into a number of given categories, consider the following equations:

a) $^{234}_{90}Th \rightarrow ^{234}_{91}Pa + ^{0}_{-1}e.$

b) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H.$

c) $^{14}_{7}N + ^{4}_{2}He + Q \rightarrow ^{17}_{8}O + ^{1}_{1}H.$

d) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + Energy.$

e) $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + Energy.$

f) $^{24}_{11}Na + ^{4}_{2}He \rightarrow [^{28}_{13}Al] \rightarrow ^{26}_{13}Al + 2^{1}_{0}n.$

g) $^{63}_{29}Cu + ^{4}_{2}He \rightarrow ^{37}_{17}Cl + 14^{1}_{1}H + 16^{1}_{0}n.$

By use of appropriate equations, write brief notes on the following

1) Natural versus artificial nuclear reactions (5mks)
2) Particle-particle versus spallation reaction. (5mks)
3) Fission versus fusion reactions. (5mks)
4) Endoergic versus exoergic reactions. (5mks)

Question Three:

i) Complete the notations for the following nuclear processes by filling in what x is, write accompanying equations for each process. (3mks)

a) ^{24}Mg(d,α)x, ^{40}Ar(α ,p)x, ^{130}Te(d ,2n)x, ^{55}Mn(n ,α)x, ^{59}Co(n ,α)x, ^{9}Be (α, x) ^{12}C.

ii) An isotopic species of lithium hydride **$^{6}Li^{2}H$** is a potential nuclear fuel, on the basis of the following reaction. $^{6}_{3}Li + ^{2}_{1}H \rightarrow 2^{4}_{2}He.$

Calculate the expected power production in watts associated with the consumption of 1.00g **$^{6}Li^{2}H$** per day (assume 100% efficiency in the process) (nuclidic masses **^{6}Li = 6.01512, ^{2}H = 2.01410, ^{4}He = 4.00260 amu**) (6 marks)

iii) State six main points that conclude the theory of disintegration. (6 marks)

iv) Sketch the binding energy curve and explain its importance. (5 marks)

$Mg + ^{2}_{1}H \longrightarrow ^{4}_{2}H$

$Ar + ^{4}_{2}He \longrightarrow ^{1}_{1}H$

Question Four:

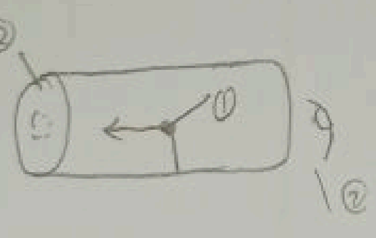
i) Describe briefly the following two devices that are used to detect radiation (uses of diagrams not necessary)

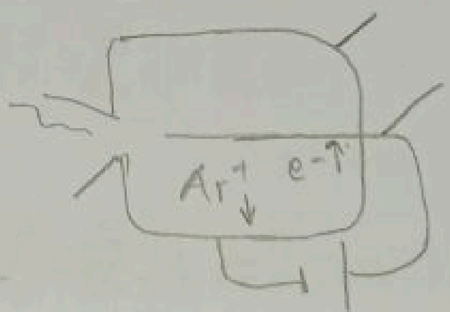
a) Scintillation counter (5 marks)

b) Geiger counter (5 marks)

ii) Two samples of equal quantity were introduced in a scintillation detector. One had a short half-life while the other had a high half-life. Which of this two will give a higher counting rate? Give a reason for this observation. (5 marks)

iii) A one kilogram ball of uranium-235 has critical mass, but the ball broken in small chunks does not. This is the phenomenon observed in a nuclear bomb, explain. (5 marks)





$i \quad j \quad k$

$\partial/\partial x \quad \partial/\partial y \quad \partial/\partial z$

$x^2 \quad 3xy^2 \quad -2xz$

PHYSICS DEPARTMENT | CAT I $-22-0$ | DATE: 2^{ND} MARCH, 2023

SPH 2200: MECHANICS II | TIME: 1 HOUR

INSTRUCTIONS: Answer all the questions

1. a) Evaluate $\hat{k}.(\hat{\imath} + \hat{\jmath})$ (2 marks)

   b) If $\vec{A} = \hat{\imath} + 3\hat{\jmath} - 2\hat{k}$ and $\vec{B} = 4\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$, find $|(2\vec{A} + \vec{B}) \cdot (\vec{A} - 2\vec{B})|$ (5 marks)

2. Use the property of the scalar product of vectors to determine the angle between the body diagonals of a unit cube situated at the origin of a rectangular coordinate system.

   (70.53)

   (5 marks)

3. If $\vec{r} = t^2\hat{\imath} - t\hat{\jmath} + t^3\hat{k}$, O is the origin and P is the point (1,-1,1), evaluate the line integral $\int_0^P \vec{r} \cdot d\vec{r}$ $= 1.5$ (5 marks)

4. a) Calculate the gradient and laplacian of the function $f(x, y, z) = x^3y^2z^3$ (4 marks)

   b) Calculate the divergence and curl of the function $\vec{v} = x^2\hat{\imath} + 3xy^2\hat{\jmath} - 2xz\hat{k}$ (4 marks)

$\alpha =$

α $I = \frac{MR^2}{2}$

FR

PHYSICS DEPARTMENT | CAT II | DATE: 28TH MARCH, 2023

SPH 2200: MECHANICS II | TIME: 1 HOUR

INSTRUCTIONS: Answer all the questions

1. Deduce the expression for kinetic energy of a rigid body rotating about an axis. A simple sketch is necessary. A grind-stone has a moment of inertia of 6×10^2 kgm^2 about its axis. A constant couple is applied and its speed increases to 150 r.p.m in 5 seconds after starting from rest. Calculate the couple. (10 marks)
2. Write the expression for moment of inertia of a solid cylinder of mass M and radius R.
   A flexible rope is wrapped several times around a solid cylinder of mass 25 kg and diameter 0.16 m which rotates without friction about a fixed horizontal axis. The free end of the rope is pulled with a constant force of 6 N for a distance 1.5 m. If the cylinder is initially at rest, calculate the final angular velocity of the cylinder and final speed of the rope. Give a sketch of the arrangement. (10 marks)
3. A circular disc of mass M and radius r is set rolling on a table. If ω is the angular velocity, show that its total energy E is given by $E = \frac{3}{4}Mr^2\omega^2$ (5 marks)
4. Two particles of masses $m_1 = 0.002$ kg and $m_2 = 0.0002$kg are separated by a distance $r = 0.05$ m. Calculate the moment of inertia of the system about an axis passing through the centre of mass and perpendicular to the line joining the two masses. (5 marks)

$FD = MR^2\alpha$

$\alpha =$

W1-2-60-1-6

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
UNIVERSITY EXAMINATIONS 2022/2023

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICAL SCIENCE, GEOPHYSICS, CONTROL AND INSTRUMENTATION, RENEWABLE & ENVIROMENTAL PHYSICS AND ANALYTICAL CHEMISTRY.

SPH 2200: MECHANICS II

DATE: APRIL 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer question one (compulsory) and any other two questions

Take acceleration due to gravity $g = 9.81\ ms^{-2}$

QUESTION ONE (30 MARKS)

(a) Evaluate $\hat{k}.(\hat{\imath} + \hat{\jmath})$ =0 (2 marks)

(b) Use the property of the scalar product of vectors to determine the angle between the body diagonals of a unit cube situated at the origin of a rectangular coordinate system (5 marks)

70.529°

(c) A particle moves along a space curve such that its displacement r is given by:

$$r = (t^2 + t)i + (3t - 2)j + (2t^3 - 4t^2)k$$

Determine velocity, speed and acceleration at $t = 2$ seconds a=v-u/m (6 marks)

$(2t+1)i + (3-0)j + (6t^2-8t)k$

$2i + 0j + (12t-8)k$

(d) Two vectors A and B are given by:

$A = 4i + 3j + k$ and $B = 2i - j + 2k$. Calculate:

(i) $A \cdot B$ 7

(ii) $A \times B$ $7i - 6j - 10k$

(iii) The angle between vectors A and B (6 marks)

62.77°

$$\begin{vmatrix} i & j & k \\ 4 & 3 & 1 \\ 2 & -1 & 2 \end{vmatrix}$$

$i(6+1) - j(8-2) + k(\cancel{8}-4-6)$

$7i - 6j -$

(e) A circular disc of mass M and radius r is set rolling on a table. If ω is the angular velocity, show that its total energy E is given by $= \frac{3}{4}Mr^2\omega^2$. (5 marks)

(f) Two particles of masses $m_1 = 0.002$ kg and $m_2 = 0.0002$kg are separated by a distance $r = 0.05$ m. Calculate the moment of inertia of the system about an axis passing through the centre of mass and perpendicular to the line joining the two masses. (6 marks)

QUESTION TWO (20 MARKS)

a) If $\vec{r} = t^2\hat{i} - t\hat{j} + t^3\hat{k}$, O is the origin and p is the point $(1, -1, 1)$, evaluate the line integral $\int_0^P \vec{r}.d\vec{r}$ $2ti - j + 3t^2 k$ $2t$ (5 marks)

b) Calculate the curl and divergence for the vector field given as:
$F = (x + y)i + (y - x)j - 2zk$ (6 marks)

$1+0+1-0-2$

c) Given $\vec{R} = \sin t\hat{i} + \cos t\hat{j} + t\hat{k}$ find $\left|\frac{d^2\vec{R}}{dt^2}\right|$ (4 marks)

d) If $\vec{R}(t) = (3t^2 - t)\hat{i} + (2 - 6t)\hat{j} - 4t\hat{k}$ find $\int_2^4 \vec{R}(t)dt$ (5 marks)

QUESTION THREE (20 MARKS)

$L = I\omega$

(a) A particle at position $\vec{r}$ with respect to the origin of a rectangular co-ordinate system has a rotatory motion about z-axis due to a force $\vec{F}$ giving it momentum $\vec{P}$. Derive the rotational kinematic relation to deduce the conservation theorem from angular momentum (7 marks)

*??

(b) An automobile engine develops 7.5×10^4 watts power when rotating at a speed of 1800 revolutions per minute. Calculate the torque it delivers. $P = MV$ (3 marks)

(c) (i) Deduce the expression for kinetic energy of a rigid body rotating about an axis. A simple sketch is necessary. (5 marks)

(ii) A grind-stone has a moment of inertia of 6×10^2 kgm^{2}about its axis. A constant couple is applied and its speed increases to 150 revolutions per minute in 10 seconds after starting from rest. Calculate the couple (5 marks)

QUESTION FOUR (20 MARKS)

$V =$ $x a_y - y a_x$ x $V = r\omega$ $x1$

a) Derive an expression for the moment of inertia of a solid cylinder about an axis passing through its centre and perpendicular to its own axis of symmetry. If the

$$\begin{array}{ccc} i & j & k \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x+y & y-x & -2z \end{array}$$

(M,g) $1+0+1-0-2$

moment of inertia is to be a minimum, determine the ratio $\frac{L}{R}$, when the mass of the cylinder is kept constant (symbols have their usual meanings). (10 marks)

b) A flexible rope is wrapped several times around a solid cylinder of mass 50 kg and diameter 0.12 m which rotates without friction about a fixed horizontal axis. The free end of the rope is pulled with a constant force of 9 N for a distance 2 m. If the cylinder is initially at rest, calculate the final angular velocity of the cylinder and find final speed of the rope. Give a sketch of the arrangement. (10 marks)

$^{3}-\frac{t^2}{2}) i + (2t - \frac{6t^2}{2}) - \frac{4t^2}{2}$

$-\frac{1}{2}t^2) i + (2t - 3t^2) j - (2t^2) k \Big|_2^4$

$\frac{t4}{2} \mp \frac{t^2}{2} + \frac{t6}{2}$

$\theta_K = \theta_C + 273.15$

SPH 2202: THERMAL PHYSICS I • Test 1 • 1 hour

The following information may be necessary: Linear expansivity for gold $= 1.42 \times 10^{-5}\ K^{-1}$, standard atmospheric pressure $= 1.013 \times 10^{5}\ Pa \equiv 1\ atm$, volume expansivity for copper $= 4.95 \times 10^{-5}\ K^{-1}$, isothermal compressibility for copper $= 6.17 \times 10^{-12}\ Pa^{-1}$

1. The density of gold is 19.3 g/cm^3 at 20°C. Compute its density (in g/cm^3) at 90°C. **(3 marks)**
2. A block of copper at a pressure of 1 atm and a temperature of 10°C is kept at constant volume. If the temperature is raised by 5°C, calculate the final pressure (in atm). Assume that the volume expansivity and isothermal compressibility remain practically constant within the temperature range of 0 to 20°C. **(3 marks)**
3. Determine the temperature on the Fahrenheit scale of the normal boiling point of water, if this temperature is 99.974°C on the Celsius scale (leave your answer to 2 decimal places). **(2 marks)**
4. The temperature scale of a certain thermometer is given by the relation $t = a \ln p + b$, where a and b are constants and p is the thermometric property of the fluid in the thermometer. If at ice-point and steam-point the thermometric properties are found to be 1.5 and 7.5 respectively, determine the temperature corresponding to the thermometric property of 3.5 on the Celsius scale. **(5 marks)**

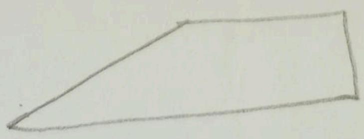
$\dot{Q} = hA(\theta_s - \theta_f)$

SPH 2202: THERMAL PHYSICS I • **Test 2** • **1 hour**

ful data: Ice point $= 0°C \equiv 273.15\,K$, Universal gas constant $R = 8.314\,Jmol^{-1}K^{-1}$, molar mass of nitrogen as $= 28$ g/mol, thermal conductivity for steel is $16.5\,J\,s^{-1}m^{-1}K^{-1}$

1. The pressure of an ideal gas decreases from P_1 to P_2 at constant volume. The gas then expands at constant pressure from volume V_1 to V_2.
   i. Draw a PV diagram to depict the process. **(2 marks)**
   ii. Given that P_1 and P_2 are $2.0 \times 10^5\ Pa$ and $1.0 \times 10^5\ Pa$ respectively, and, V_1 and V_2 are $5.0 \times 10^4\ cm^3$ and $1.0 \times 10^5\ cm^3$ respectively, determine the thermodynamic work done by the gas. **(2 marks)**
   iii. Given that the curve connecting the states (P_1, V_1) and (P_2, V_2) is an isotherm, determine the amount of heat energy added to the system. Comment on your answer. **(3 marks)**
2. A cylinder contains 7.0 g of nitrogen gas. Determine the thermodynamic work that must be done to compress the gas at a constant temperature of 80°C until the volume is halved. **(3 marks)**
3. One end of a 1.5 m long stainless steel rod is placed in an 850 K fire. The cross-sectional radius of the rod is 1 cm, and the cool end of the rod is at 300 K. Calculate the rate of heat transfer through the rod. **(2 marks)**
4. Calculate the value of Stefan-Boltzmann's constant if the temperature of a 40 W tungsten lamp is 2170°C and the effective surface area of the filament is 6.6×10^{-5} m^2. Take the energy radiated to be 0.31 of that from a blackbody in similar conditions and that any effect due to radiation from the glass envelop is negligible. **(2 marks)**

$\dot{Q} = hA(\theta_s - \theta_f)$



$\dot{Q} = -kA\,d\theta$

W1-2-60-1-6

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
University Examinations 2022/2023

Second Year Second Semester Examination for the Degrees of Bachelor of Science in Physical Science, Control & Instrumentation, Renewable Energy & Environmental Physics, Geophysics, and Analytical Chemistry

SPH 2202: THERMAL PHYSICS I

April 2023 **Time: 2 Hours**

Instructions: Attempt **THREE QUESTIONS: Question ONE is compulsory**. It carries 30 marks. **Attempt any other two questions**. Each question carries 20 marks.

You may find the following information useful:

Volume expansivities: $\beta_{paraffin} = 590 \times 10^{-6} K^{-1}$, $\beta_{carbon\,steel} = 32.4 \times 10^{-6} K^{-1}$, $\beta_{iron} = 35.5 \times 10^{-6} K^{-1}$, $\beta_{copper} = 4.95 \times 10^{-5}\ K^{-1}$, $\beta_{glass} = 27 \times 10^{-6} K^{-1}$, $\beta_{water} = 207 \times 10^{-6} K^{-1}$.

Linear expansivity: $\alpha_{gold} = 1.42 \times 10^{-5}\ K^{-1}$, $\alpha_{Al} = 23 \times 10^{-6} K^{-1}$

Pressure: Standard atmospheric pressure = $1\ atm$, $1\ atm\ = 1.013 \times 10^5\ Pa$

Ice point = $0°C \equiv 273.15\ K$, Steam point = $100°C \equiv 373.15\ K$, Triple point of water = $273.16\ K$

Universal gas constant $R = 8.314\ Jmol^{-1}K^{-1}$

Specific heat capacity: $c_{ethanol} = 2.5\ Jg^{-1}°C^{-1}$

Molar heat capacity of sodium chloride = $49.9\ Jmol^{-1}K^{-1}$

Molar mass of sodium chloride = $58.5\ g\ mol^{-1}$.

Thermal conductivity: $K_{steel} = 16.5\ Wm^{-1}K^{-1}$, $K_{brick} = 0.51\ Wm^{-1}K^{-1}$, $K_{concrete} = 0.8\ Wm^{-1}K^{-1}$, $K_{styrofoam} = 0.035\ Wm^{-1}K^{-1}$

Wien's constant = $2.898 \times 10^{-3}\ mK$

Stefan – Boltzmann's constant = $5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$

$\pi = 3.142$

QUESTION ONE (COMPULSORY – 30 MARKS)

(a)

(i) Two 20 L containers, one made of carbon steel and the other made of iron are to be completely filled up with paraffin when the temperature is 10°C. Determine the setup that would result in most spillage (specify the amount in L) when the temperature is made to rise to 30°C. (answer to 4 d.p.) **(4 mks)**

(ii) The density of gold is 19.3 g/cm^3 at 20°C. Compute its density (in g/cm^3) at 90°C. (answer to 2 d.p.) **(4 mks)**

(b)

(i) A temperature scale of a certain thermometer is given by the relation $t = a \cdot \ln p + b$ where, t is temperature, a and b are constants and p is the thermometric property of the fluid in the thermometer. If at ice point and steam point the thermometric properties are found to be 1.5 and 7.5 respectively, determine the temperature corresponding to the thermometric property of 3.5 on the Celsius scale. (answer to 2 d.p.) **(4 mks)**

(ii) The thermometric substance of a certain thermometer has a length of 5 cm when it is immersed in water at triple point. Determine,

I. The temperature (in K) when the length is 6.0 cm. (answer to 2 d.p.) **(2 mks)**

II. The length (in cm) when the thermometer is immersed in a liquid at 100°C. (answer to 2 d.p.) **(2 mks)**

(c)

(i) A balloon contains 0.3 mole of helium. It rises, while maintaining a constant 300 K temperature, to an altitude where its volume has expanded 5 times. Determine the amount of work done in the process. (answer to 1 d.p.) **(2 mks)**

(ii) A thermodynamic system with volume $V_1 = 500\ cm^3$ undergoes an isovolumetric decrease in pressure from $P_1 = 3\ atm$ to $P_2 = 1\ atm$ followed by an isobaric expansion to $V_2 = 2000\ cm^3$. Calculate the work done during the process. (answer to 3 s.f.) **(2 mks)**

(iii) An ideal gas undergoes an isobaric expansion at 2.5 kPa from 1 m³ to 3 m³. Given that it was initially at 300 K and 12.5 kJ of heat energy is transferred to the gas, determine the change in its internal energy. **(2 mks)**

(d) The inner surface of a brick wall is at 60°C and the outer surface is at 35°C. Calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. (answer to 4 s.f.) **(2 mks)**

(e)

(i) State Wien's displacement law. **(1 mk)**

(ii) Assuming the sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.49\ \mu m$, calculate, the surface temperature of the sun. (answer to 4 s.f.) **(2 mks)**

(iii) A blackbody at 1373°C has the wavelength λ_m corresponding to maximum emission equal to 1.78 micron. Assuming the moon to be a blackbody with λ_m of 14 micron, calculate its temperature in Kelvin. **(3 mks)**

QUESTION TWO (20 MARKS)

$dV = VBdT - VkdP$

(a)

(i) Show that for a hydrostatic system, $\left(\frac{\partial P}{\partial T}\right)_V = \frac{\beta}{K}$, where, P, V and T are thermodynamic variables, β is the volume expansivity and K is the isothermal compressibility. **(4 mks)**

$dV = -VkdP$

(ii) Show that for an ideal gas, the volume expansivity, $\beta = \frac{1}{T}$ **(3 mks)**

$dP = -\frac{1}{Vk}$

(b) A glass of water with volume 1 liter is completely filled at 5°C. Determine the amount of water that will spill out of the glass when the temperature is raised to 85°C. Leave your answer in liters and in 3 d.p. **(4 mks)**

$dT =$

$P = P(V,T)$

$VkdP = VBdT$

$K = 6{\cdot}17 \times 10^{-12}$

(i) A vessel holds a block of copper at constant volume. The copper block is initially at a pressure of 1 atm and a temperature of 5°C. Given that the vessel has a negligibly small thermal expansivity and can withstand a maximum pressure of 1000 atm, determine the highest temperature to which the system may be raised. (answer to 1 d.p.). **(3 mks)**

(ii) An aluminum rod has a length of exactly one meter at 300 K. Determine its final length when it is placed in a 400°C oven. (answer to 4 d.p.) **(2 mks)**

(d)

(i) If the normal boiling point of water is 99.974°C on the Celsius scale, determine the temperature on the Fahrenheit scale. (answer to 2 d.p.). **(2 mks)**

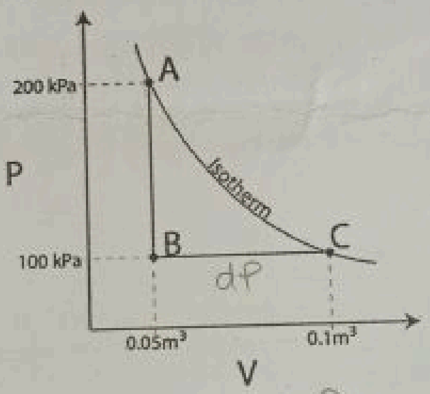
(ii) A constant volume-gas thermometer gives readings of $1.333 \times 10^5\ Pa$, $1.821 \times 10^5\ Pa$ and $1.528 \times 10^5\ Pa$, at ice point, steam point and when immersed in a boiling liquid respectively. Calculate the temperature in °C at which the liquid boils. (answer to 2 d.p.). **(2 mks)**

QUESTION THREE (20 MARKS)

(a)

(i) Heat is removed from an ideal gas as its pressure drops from $200\ kPa$ to $100\ kPa$ as shown in the PV diagram below. The gas then expands from a volume of $0.05\ m^3$ to $0.1\ m^3$ as shown.

$k = 6{\cdot}1\ Pa^{-1}$



$B = 3\alpha$

$\underline{K}$

in P

Determine,

I. The work done by the gas. **(2 mks)**

II. The heat added to the gas. **(2 mks)**

(ii) 10 moles of an ideal gas are compressed isothermally and reversibly from a pressure of 1 *atm* to 10 *atm* at 300 K. Determine the work done. **(2 mks)**

(b)

(i) During a certain thermodynamic process, the initial temperature of 150 g of ethanol was 22°C. Determine the final temperature (in °C) of the ethanol if 3240 J of heat energy was needed to raise its temperature. **(2 mks)**

(ii) The mean specific heat capacity of a certain gas during a certain process is given by,

$$c = (0.4 + 0.004\,T)\ kJkg^{-1}K^{-1}$$

If the mass of the gas is 6 kg and its temperature changes from 25°C to 125°C, determine,

I. The amount of heat energy transferred. unit mass at 1 V_i **(3 mks)**

$dT = cmdT$ compression

480 expansion = V_i $\underline{V_f}$

(2 mks)

II. Mean specific heat capacity of the gas.

(iii) Calculate the temperature increase (in K) when $750\,J$ of heat is applied to $150\,g$ of sodium chloride (answer to 3 s.f.) (2 mks)

(c) The internal energy for a certain 4 mole monatomic gas is given by $U = 1.5nRT$. Determine,

(i) The heat capacity at constant volume. (answer to 4 s.f.) (3 mks)

(ii) The heat capacity at constant pressure. (answer to 4 s.f.) (2 mks)

QUESTION FOUR (20 MARKS)

(a)

(i) One end of a $1.5\,m$ long steel rod is placed in fire that is at $850\,K$ temperature. The cross-sectional radius of the rod is $1\,cm$, and the cool end of the rod is at $300\,K$. Calculate the rate of heat transfer through the rod. (answer to 1 d.p.) **(2 mks)**

(ii) Show that the total thermal resistance of a wall that is a composite of two walls arranged in parallel can be given by:

$$R_{thermal\ (total)} = \frac{L}{K_1 \cdot A_1 + K_2 \cdot A_2}$$

Where, $L \equiv$ length of the wall, K_1 and $K_2 \equiv$ thermal conductivities of wall 1 and wall 2 respectively, A_1 and $A_2 \equiv$ cross-sectional areas of wall 1 and wall 2 respectively. **(5 mks)**

(iii) The wall of a certain building is a composite of two walls, a $0.3\,m$ thick outer brick wall and a $0.4\,m$ thick inner Styrofoam wall. Given that the walls have the same cross-sectional area of $15\,m^2$, temperatures of 24°C and 5°C at the inner and outer surfaces of the composite respectively, and a temperature of 23.4°C at the interface, determine the rate of heat loss through the wall using the concept of thermal resistance. **(3 mks)**

(b)

(i) The temperature of a 40 W tungsten lamp (diagram below) is 2170°C and the effective surface area of the filament is $6.6 \times 10^{-5}\,m^2$. Assuming the energy radiated to be 0.31 of that from a black body in similar conditions and that any effect due to radiation from the glass envelop is negligible, determine the value of Stefan-Boltzmann constant. **(2 mks)**

(ii) A black body at 3000 K emits radiation. Calculate the following:

I. Wave length at which emission is maximum. **(2 mks)**

II. Emissive power per m^2. **(2 mks)**

III. Emissive power if it is assumed to be a real surface having emissivity equal to 0.85. **(2 mks)**

(iii) Calculate the rate of heat loss by radiation per m^2 when a body initially at 1000°C is placed in a surrounding that is at 500°C. Assume the emissivity of the body to be 0.42. **(2 mks)**