# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 331: STRENGTH OF MATERIALS IIA

DATE: JANUARY 31, 2012 TIME: 11.15 A.M. – 1.15 P.M

INSTRUCTIONS:

- All questions carry equal marks
- Answer any THREE questions.
- Poisson's ratio for steel v=0.25
- Modulus of Elasticity for Steel Es = 200kN/m$^2$.



1. (a) Using first principles show that $Ix = \frac{bh^3}{36}$ for the triangular section shown in Fig. Q 1. (8 marks

(b) The section shown in Fig. Q1 is subjected to a vertical shear force of V = 120kN. Given b = 60 mm, h = 100 mm, calculate the maxim shear stress in the cross section. (8 marks

(c) A rectangular cross section of 1.0 metre length is subjected to a uniform bending moment of $M_x$ = 50KNm. The section has $I_x$ = 5E6 mm$^4$.
Calculate the strain energy stored in the section. (4 marks)

2. (a) Distinguish between principal and centroidal axes. (4 marks)

(b) The zed section shown in Fig Q2. Calculate the following:-

(i) The centroidal moments of area $I_{xx}$, $I_{yy}$ and $I_{xy}$. (8 marks)

(ii) The principal moments of area $I_{uu}$ and $i_{vv}$. (6 marks)

(iii) The inclination of the principal axes from the centroidal axe (2 marks)

3. The inverted T section shown in Fig Q3 has the following section properties; A = 1900 mm$^2$, $I_{xx}$= 1.80E 6mm$^4$, $I_{yy}$ = 1.137 E6 mm$^4$, $I_{uu}$ = 2.147E6 mm

$I_{vv}$= 0.79E6 mm$^4$.

The section is subjected to a sagging moment of magnitude $M_x$ = 3KNm and compressive axial force of F = 38KN applied through the centroid.
Calculate the combined stress at A and B due to the bending moment and th axial force. (20 marks

4. (a) The strut shown in Fig Q4A has the buckled profile $y - 4\ell^3 x - x^4 - 3\ell^4$ and has a uniform cross section. Use the energy method to obtain a expression of the critical load per. (14mark)



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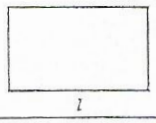
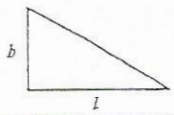
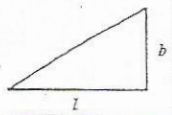
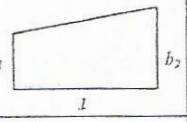
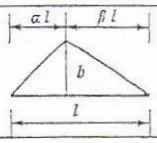
VALUES OF THE PRODUCT INTEGRAL $\int M_i M_j dl$

| $M_i$ / $M_j$ |  |  |  |  |  |
|---|---|---|---|---|---|
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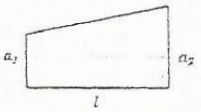
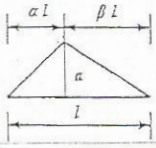
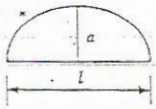
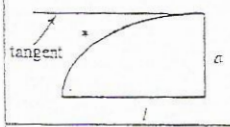
|  | $\frac{bl}{2}(a_1+a_2)$ | $\frac{bl}{6}(2a_1+a_2)$ | $\frac{bl}{6}(a_1+2a_2)$ | $\frac{l}{6}\begin{bmatrix}2a_1b_1+a_1b_2\\+a_2b_1+2a_2b_2\end{bmatrix}$ | $\frac{bl}{6}\begin{bmatrix}(1+\beta)a_1\\+(1+\alpha)a_2\end{bmatrix}$ |
|  | $\frac{abl}{2}$ | $\frac{abl}{6}(1+\beta)$ | $\frac{abl}{6}(1+\alpha)$ | $\frac{al}{6}\begin{bmatrix}(1+\beta)b_1\\+(1+\alpha)b_2\end{bmatrix}$ | $\frac{abl}{3}$ |
|  | $\frac{2}{3}abl$ | $\frac{abl}{3}$ | $\frac{abl}{3}$ | $\frac{al}{3}(b_1+b_2)$ | $\frac{abl}{3}(1+\alpha\beta)$ |
|  | $\frac{2}{3}abl$ | $\frac{abl}{4}$ | $\frac{5}{12}abl$ | $\frac{al}{12}(3b_1+5b_2)$ | $\frac{abl}{12}(5-\beta-\beta^2)$ |

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| | $l$ | $l$ | $l$ | $l$ | $l$ |
|---|---|---|---|---|---|
| $\frac{abl}{2}$ | $\frac{al}{2}(b_1+b_2)$ | $\frac{abl}{2}$ | $\frac{abl}{2}$ | $abl$ | $\frac{bl}{2}(a_1+a_2)$ |
| $\frac{abl}{2}$ | $\frac{l}{6}\left[\begin{array}{l}2a_1b_1+a_1b_2\\+a_2b_1+2a_2b_2\end{array}\right]$ | $\frac{bl}{6}(a_1+2a_2)$ | $\frac{bl}{6}(2a_1+a_2)$ | $\frac{bl}{2}(a_1+a_2)$ |
| $\frac{abl}{3}$ | $\frac{al}{6}\left[\begin{array}{l}(1+\beta)b_1\\+(1+\alpha)b_2\end{array}\right]$ | $\frac{abl}{6}(1+\alpha)$ | $\frac{abl}{6}(1+\beta)$ | $\frac{abl}{2}$ |
| $\frac{abl}{3}(1+\alpha\beta)$ | $\frac{al}{3}(b_1+b_2)$ | $\frac{abl}{3}$ | $\frac{abl}{3}$ | $\frac{2}{3}abl$ |
| $\frac{abl}{12}(5-\beta-\beta^2)$ | $\frac{al}{12}(3b_1+5b_2)$ | $\frac{5}{12}abl$ | $\frac{abl}{4}$ | $\frac{2}{3}abl$ |
| $\frac{abl}{12}(1+\alpha+\alpha^2)$ | $\frac{al}{12}(b_1+3b_2)$ | $\frac{abl}{4}$ | $\frac{abl}{12}$ | $\frac{abl}{3}$ |
| $\frac{bl}{6}\left[\begin{array}{l}(1+\beta)a_1\\+(1+\alpha)a_2\end{array}\right]$ | $\frac{l}{6}\left[\begin{array}{l}2a_1b_1+a_1b_2\\+a_2b_1+2a_2b_2\end{array}\right]$ | $\frac{bl}{6}(a_1+2a_2)$ | $\frac{bl}{6}(2a_1+a_2)$ | $\frac{bl}{2}(a_1+a_2)$ |
| $\frac{abl}{3}$ | $\frac{al}{6}\left[\begin{array}{l}(1+\beta)b_1\\+(1+\alpha)b_2\end{array}\right]$ | $\frac{abl}{6}(1+\alpha)$ | $\frac{abl}{6}(1+\beta)$ | $\frac{abl}{2}$ |
| $\frac{abl}{3}(1+\alpha\beta)$ | $\frac{al}{3}(b_1+b_2)$ | $\frac{abl}{3}$ | $\frac{abl}{3}$ | $\frac{2}{3}abl$ |
| $\frac{abl}{12}(5-\beta-\beta^2)$ | $\frac{al}{12}(3b_1+5b_2)$ | $\frac{5}{12}abl$ | $\frac{abl}{4}$ | $\frac{2}{3}abl$ |
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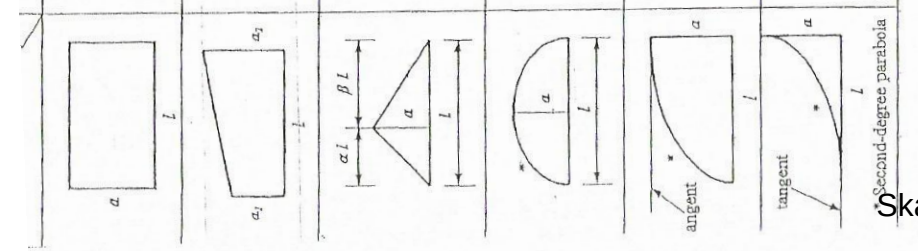




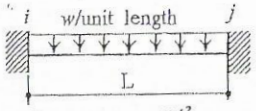

For any two adjacent spans, $a$ and $b$, of a continuous beam of constant flexural rigidity $EI$ and having supports 1, 2 and 3, the three-moment equation is

$$M_1(L_a)+2M_2(L_a+L_b)+M_3(L_b)=-6\left[\left(\frac{A_a\bar{x}_a}{L_a}\right)+\left(\frac{A_b\bar{x}_b'}{L_b}\right)\right]+6EI\left[\left(\frac{\delta_2-\delta_1}{L_a}\right)+\left(\frac{\delta_2-\delta_3}{L_b}\right)\right]\ldots\ldots eqn(1)$$

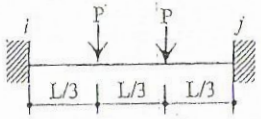
For a flexural member $ij$ of length $L$ and stiffness $K$, the slope-deflection equation is

$$M_{ij}=2EK\left(2\theta_i+\theta_j-\frac{3\delta}{L}\right)+M_{ij}^F\ldots\ldots\ldots\ldots eqn\ (2)$$

Fixed End Moments:




$$M_{ij}^F=-M_{ji}^F=\frac{-wL^2}{12}$$




$$M_{ij}^F=-M_{ji}^F=\frac{-2PL}{9}$$

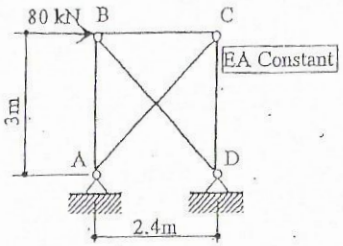



FIGURE Q1.

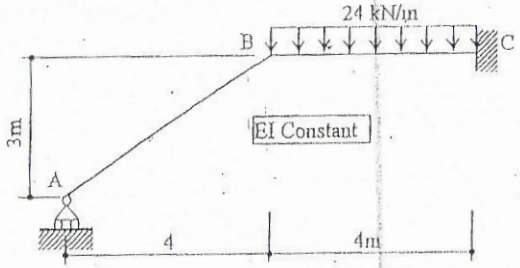



FIGURE Q2.

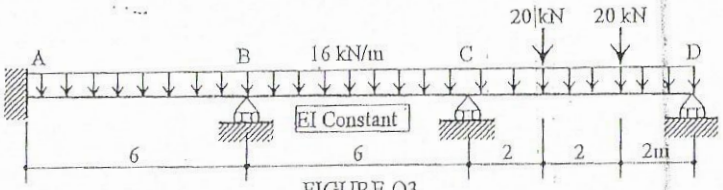



FIGURE Q3.

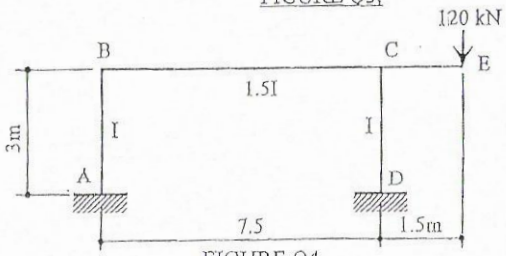



FIGURE Q4.

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# UNIVERSITY OF NAIROBI

SUPPLEMENTARY EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 301 : THEORY OF STRUCTURES IIA

DATE: OCTOBER 25, 2010 TIME: 2.00 P.M. – 4.00 P.M.

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INSTRUCTIONS:

1. Attempt ALL THREE (3) questions.
2. All questions carry equal marks.
3. Non-programmable electronic calculators are allowed.

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1. The pin-jointed steel frame shown ABCD in figure Q1 is pinned to supports at A and D. During assembly, member BC was found to be too long by 3 mm and had to be forced into position. Using any suitable energy method, calculate the forces in all members when the frame is subjected to a horizontal load of 120 kN as shown. (20 marks)

   Take : Young's modulus for steel $E = 205\ kN/mm^2$
   Cross-section area of each member $A = 600mm^2$

2. The beam ABC shown in figure Q2 is rigidly fixed to the support at A, simply supported at C and continuous over the knife-edge roller support at B. A uniformly distributed load of 40 kN/m intensity is supported along span AB. Using EITHER energy methods OR the 3-moment equation, determine all reaction components and moments over the supports and sketch the bending moment diagram clearly indicating your sign convention. The flexural rigidity EI is constant throughout the beam. (20 marks)

3. Figure Q3 shows a rigid-jointed frame ABCD, rigidly fixed to supports at A and D and supported on a pin roller at C. The frame supports a uniformly distributed load of 50kN/m intensity along the beam ABC. The flexural rigidity of the beam ABC is twice that of the column BD. Given that axial strains are negligible, obtain the bending moments at the joints and supports using the slope-deflection equations given and sketch the moment diagram indicating your sign convention clearly. (20 marks)

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For any two adjacent spans, $a$ and $b$, of a continuous beam of constant flexural rigidit and having supports 1, 2 and 3,

$$M_1(L_a)+2M_2(L_a+L_b)+M_3(L_b)=-6\left[\left(\frac{A_a\bar{x}_a}{L_a}\right)+\left(\frac{A_b\bar{x}_b}{L_b}\right)\right]+6EI\left[\left(\frac{\delta_2-\delta_1}{L_a}\right)+\left(\frac{\delta_2-\delta_3}{L_b}\right)\right]\text{.....eq}$$

For any member $ij$ of a rigid frame of length $L$, the end moments are given

$$M_{ij}=2EK\left(2\theta_i+\theta_j-\frac{3\delta}{L}\right)+M_{ij}^F\text{.....}eqn(2)$$

$$M_{ji}=2EK\left(2\theta_j+\theta_i-\frac{3\delta}{L}\right)+M_{ji}^F\text{.....}eqn(3)$$

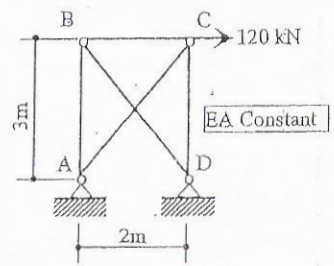


FIGURE Q1.

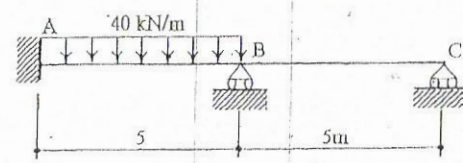


FIGURE Q2.

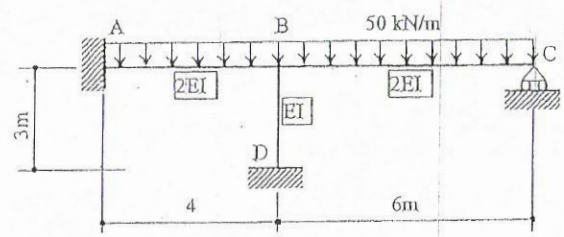


FIGURE Q3.

# UNIVERSITY OF NAIROBI

## FIRST SEMESTER EXAMINATIONS 2005/2006

## THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF ENVIRONMENTAL AND BIOSYSTEMS ENGINEERING

## FEB 331: APPLIED FLUID MECHANICS

DATE: 24TH FEBRUARY, 2006 TIME: 11.15 A.M. – 1.15 P.M

INSTRUCTIONS:

1. Answer any three questions
2. All questions carry equal marks
3. Reasonable assumptions may be made
4. NEAT WORKING is emphasized.

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1. a) A rectangular open channel whose width is 4.5 m and having a slope of 1:800 (vertical : horizontal) conveys water at a depth of 1.2 m, and has a chezy constant C of 49 (S.I. Units). Find the mean velocity of flow and the discharge per unit width of the channel. [4 marks]

b) i) I. Define critical flow. [2 marks]

II. Obtain from first principles an equation for the relationship between critical depth and specific energy for a constant discharge per unit width. Plot the specific energy curve for a given flow per unit width and show on the graph the critical point. [9 marks]

ii) Water is flowing in a rectangular channel which is 2 m width and carrying a flow of 2 $m^3/s$. The channel at some section is constricted to a width of 0.5 m. Neglecting losses, and assuming that the constriction gives critical flow, determine the water depth in the constriction and the depth upstream. [5 marks]

2. a) i) Show from first principles that the theoretical flow rate through a suppressed rectangular weir is given by $Q = 2/3.B.\sqrt{(2g)}.H^{3/2}$ where B is width of weir and H is water level above crest. [6 marks]

ii) Discuss why the actual discharge would be lower than the value obtained in 2. a. (i) above. [2 marks]

iii) For discharge over a sharp-crested suppressed rectangular weir of 0.14 $m^3/s$ with a water level above crest of 23 cm, calculate the width of weir required (Take $C_d$ as 0.6). [3 marks]

b) i) By use of sketches, show the profiles of the three M backwater curves, indicating the critical depth positions. [3 marks]

ii) A rectangular channel 1.25 m wide and 30 m long with a flat horizontal slope carries a flow of 0.5 $m^3/s$, and terminates in a free discharge. Determine for the backwater profile depths 0.300 m and 0.320 m the average distance upstream of the critical discharge point. 6 marks]

3. a) i) Define the three similarity laws applied to modeling. [3 marks]

ii) Using the Buckingham Π theorem approach for dimensional analysis, determine the inter-relationship for the parameters affecting the drag force $F_d$ of a sphere moving through a viscous fluid, given that the fluid properties and physical properties of importance within the system include fluid density ($\rho$), viscosity ($\mu$), sphere diameter (D), and sphere velocity (V). [9 marks]

b) A smooth flat plate 15 cm wide and 50 cm long is placed longitudinally in a stream of crude oil of specific gravity 0.925 at 25°C flowing with undisturbed velocity of 60 cm/s. ($\upsilon_{oil}$ at 20°C is $0.93 \times 10^{-4}$ $m^2/s$). Find:

i) Frictional drag on one side of the plate. [4 marks]

ii) Thickness of the boundary layer and shear stress at the trailing edge of the plate. [4 marks]

4. a) A turbine with $\sigma_c = 0.1$ is to be installed at a location where barometric pressure is 1 bar, with a maximum temperature of 40°C ($P_v = 0.07375$ bar), and the net

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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 321 : FLUID MECHANICS IIA

DATE: 9 FEBRUARY, 2010 TIME: 11.15 A.M. – 1.15 P.M.

INSTRUCTIONS

1. **Attempt THREE Questions.**
2. **All questions carry EQUAL marks.**
3. **Density of water is 1000Kg/m$^3$.**
4. **Acceleration due to gravity is 9.81 m/s$^2$**
5. **Reasonable assumptions may be made where necessary.**

Q.1.(a) Starting with the Bernoelle and continuity equations, show that the following expression gives the discharge measured by a venturimeter.

$$Q = Cd\, A_1 A_2 \sqrt{\frac{2g\left(\frac{P_1 - P_2}{eg} + Z_1 - Z_2\right)}{A_1^2 - A_2^2}}$$

Where the notations have usual meaning. (7 marks)

(b) A horizontal venturimeter is used to measure the flow of water in a 200mm diameter pipe. The throat diameter of the venturimeter is 80mm and the discharge coefficient is 0.85. If the pressure difference between the two measurement points is 10cm of mercury, calculate the average velocity in the pipe. Assume the relation density of mercury is 13.6. (8 marks)

(c) The velocity of the water flowing in the same pipe is also measured using a pitot-static tube located centrally in the flow. If the height measured on the attached manometer is 60mm and the relative density of the manometer fluid is 1.45, determine the velocity of the water. (8 marks)

(d) Explain why the velocity measured by the pitot-static tube is higher than that measured by the venturimeter. (2 marks)



Q.2.(a) Derive the following expression for the discharge over a rectangular weir. Start with Bernoelli's equation and state all the assumptions hat you make.

$$Q = Cd\, \tfrac{2}{3} B\sqrt{2gH^{\frac{3}{2}}}$$ (7 marks)

(b) Water is flowing over a sharp-crested rectangular weir of width 50cm into a tank with cross-sectional area 0.6m$^2$. After a period of 30s the depth of water in the tank is 1.4m. Assuming a discharge coefficient of 0.9 determine the height of the water above the weir. (9 marks)

(c) If the rectangular weir is replaced by a 90° notch weir with the same head and a discharge coefficient of 0.8, calculate the depth increase of the water in tank after 30s. (9 marks)

Q.3.(a) Derive an expression for the loss of head due to friction in a pipeline in terms of the velocity head assuming that the frictional resistance per unit area of pipe wall is proportional to the square of the mean velocity of flow. (15 marks)

(b) Find the loss of head due to friction in a pipe 450m long and 225 mm diameter with the discharge is 4.0 m$^3$/min and the resistance coefficient f = 0.015. (10 marks)

Q.4. Two reservoirs are connected by a pipeline which 125 mm dia for the first 60m and 200 mm in diameter for the remaining 150m. The entrance and exit are sharp and the change of section is sudden. The water surface in the upper reservoir is 48m above the lower. Tabulate the losses of head which occur and calculate the rate of flow in m$^3$/s. Friction coefficient f = 0.012 for both pipes. Draw also the hydraulic gradient and the total energy gradient. (25 marks)



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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 321: FLUID MECHANICS IIA

DATE: JANUARY 24, 2012 TIME: 11.15. A.M. – 1.15. P.M.

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NOTES TO CANDIDATES

1. Attempt any THREE Questions.
2. All questions carry equal marks.
3. Density of water is 1,000 kg/m$^3$
4. Acceleration due to gravity is 9.81m/s$^2$
5. Reasonable assumptions may be made where necessary.
6. Non-programmable electronic calculators may be used.

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1. a) Establish Bernoulli's equation for the streamline motion of a fluid. *[12 marks]*

b) Show that when water is issuing steadily from an re - entrant orifice in the bottom of a tank, the area of the jet at the vena contracta is ½ of the area of the orifice. *[8 marks]*

2. a) Show that a venturi meter the quantity of water passing through the meter will be only proportional to the root of the "venturi head" if the head lost in friction is proportional to the head lost due to increased velocity. *[10 marks]*

b) A venturi meter placed in a 75mm diameter pipe has a throat diameter of 25mm. The constant of the meter is 0.97. Determine the discharge when the venturi head is 400mm of water. *[5 marks]*

c) If the frictional loss in the diverging cone is double that in the conveying cone, find the total head loss in the meter due to friction when the water is passing at the above rate. *[5 marks]*

3. a). Prove that for a slow flow through a pipe.

$$\frac{\rho g i d^2}{\bar{V}\mu} = 32$$

Where $\bar{V}$ = mean velocity
$\rho$ = density of fluid
$i$ = energy gradient
$\mu$ = coefficient of dynamic viscosity.

*[12 mark*

b) Find the flow of oil $\eta = 0.5$g cm$^{-1}$sec$^{-1}$, density = 0.8 g/cm$^3$ through a pipe diameter 0.9 cm and 12m long when the head lost is 75cm.

4. a) Show that the discharge over a sharp-edged V-notch is theoretically proportional to the head raised to an index power of 2.5. *[10 marks*

b) A sharp-edge V-notch inserted in the side of a rectangular tank 3.6m and 1.2m abroad gives calibration $Q = 1.43\ H^{2.5}$ where $Q$ is measured in cubic meters per second and $H$ in meters. Find how long it will take to reduce the head in the tank from 300mm to 25mm, if the water discharges freely over the notch and there is no inflow into the tank. *[10 marks*

Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2010/2011

D YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 321 : FLUID MECHANICS IIA

8TH FEBRUARY, 2011 TIME: 11.15 A.M – 1.15 P.M.

UCTIONS

Attempt THREE Questions.
All questions carry EQUAL marks.
Density of water is 1,000 kg/m$^3$
Acceleration due to gravity is 9.81 m/s$^2$
Reasonable assumption may be made where necessary.

a) Water is flowing over a sharp crested rectangular weir of width 35 cm into a cylindrical tank of diameter 75cm. In 20 seconds the depth of water in the tank rises 1.2m. Assuming a discharge coefficient of 0.9, determine the height of the water above the weir in mm. (9 marks)

b) If the discharge remains the same and the rectangular notch is replaced by a 90° notch weir with a coefficient of discharge of 0.8 and a maximum height of 18 cm would this notch be adequate to measure this discharge? (6 marks)

c) In an experiment a jet of water of diameter 200 mm is fired vertically upwards at a spring target that deflects the water at an angle of 120° to the horizontal in all directions. If a 500g mass placed on the target balances the force of the jet, what is the discharge of the jet in litres/s? (10 marks)
[Prove any formulae you use]

a) Starting with the Bernoulli and Continuity equations, show that the following expression gives the discharge measured by a venturimeter.

$$Q = CdA_1A_2\sqrt{\frac{2g(\frac{p_1-p_2}{\rho g}+z_1-z_2}{A_1^2-A_2^2}}$$



and that when a manometer is attached the discharge may be given by:

$$Q_{actual} = CdA_1A_2\sqrt{\frac{2gh(\frac{\rho_m}{\rho}-1)}{A_1^2-A_2^2}}$$ (7 marks)

(b) A vertical venturimeter is being used to measure the flow of oil of relative density 0.88 in a 200 mm diameter pipe. The throat diameter of the venturimeter is 100 mm and the discharge coefficient is 0.96. Two tapping point at the throat and entrance are 320 mm apart and the pressure difference between these is measured at 38 kN/m$^2$. What is the discharge and the velocity in the pipe? If mercury manometer were attached at the tappings points what would be the difference in Levels of the two areas of the manometer?
(Assume the relative density of mercury is 13.6). (8 marks)

(c) The velocity of the water flowing in the same pipe is also measured using a pitot – static tube located centrally in the flow. If the height measured on the attached mercury manometer is 15 mm, determine the velocity of the oil (8 marks)

(d) Explain why the velocity measured by the pitot – static tube is higher than that measured by the venturimeter. (2 marks)

Q.3. A liquid whose coefficient of viscosity is "m" flows, below the critical velocity for laminar flow in a circular pipe of diameter "d" and with mean velocity "u". Show that the pressure loss in a length of pipe is 32u m/d$^2$.
Oil of viscosity 0.05kg/ms flows through a pipe diameter 0.1 m with a velocity of 0.6m/s. Calculate the loss of pressure in a length of 120m. (25 marks)

Q.4. Two vertical cylindrical tanks of 5m and 3m diameter contain water they are joined near their bases by a pipe of diameter 5cm which is short enough to be considered an orifice with Cd of 0.6. If the 3m diameter tank initially has a level 2m higher than the other, calculate how long it will take for the levels to become equal in each tank. (25 marks)

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Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 345 : CIVIL ENGINEERING MATERIALS II

DATE: 18 FEBRUARY, 2010 TIME: 11.15 A.M. – 1.15 P.M.

INSTRUCTIONS:
1. All questions carry equal marks
2. Answer any THREE questions.

## Question 1

(a) How do the following material properties affect the quality of rock for road making?
- (i) Mineral composition and decomposition
- (ii) Grain size
- (iii) Rock structure
- (iv) Re-crystallization (8 marks)

(b) (i) Define surface dressing/treatment in road construction.
(ii) State three functions of surface dressing (5 marks)

(c) Calculate the rate of spread of tar in kg/m$^2$ and aggregates in m$^3$ per 10 m$^2$ for a surface dressing course 12mm thick. The initial voids may be taken to be 50 per cent and voids after final Compaction by traffic may be assumed to be 20 per cent. The whip-off due to traffic is 10 per cent. Binder should form 60 per cent of final voids. Specific gravity of tar is 1.2. (12 marks)

## Question 2

(a) (i) What is asphalt concrete?
(ii) State the advantages of asphalt concrete in road construction (8 marks)

(b) Describe in detail the basic properties and functions of the following components in a bituminous mixture.
- (i) Coarse aggregates
- (ii) Fine Aggregates
- (iii) Filler material, and
- (iv) Binder (8 marks)

(c) An Asphalt Concrete (AC) mix for a road-surfacing project has been prepared using the following aggregates:

| Aggregate type | % by weight | Specific gravity |
|---|---|---|
| Coarse | 60 | 2.60 |
| Fine | 30 | 2.65 |
| Filler | 10 | 2.70 |

The bitumen content for the mix was 7.5%

A field sample cored from the compacted layer weighed 3680g in air and 2060g in water. By carrying out the necessary computations, evaluate the mix for the degree of mixing and degree of compaction achieved in the field. The specific gravity of bitumen is 1.04. (9 marks)

## Question 3

(a) Briefly describe the following tests carried out on bitumen, stating the relevance of each.
- (i) Penetration test
- (ii) Ring and Ball softening test

(10 marks)

(b) Two bitumen samples, A and B have the same penetration of 85 at 25° C. However, the samples have different softening points with sample A having a ring-and-ball softening point of 54°C and while B has ring-and-ball softening point of 60°C. Plot the penetration versus temperature charts for the two binders and calculate the penetration index ($P_I$) of each.

By extension of each graph determine the Fraas breaking point for each bitumen sample. Which one of the two binders would you prefer for road construction in hot areas? Give reasons. (15 marks)

## Question 4

(a) Define the following terms used in road surfacing:
- a. Prime coats
- b. Tack coats. (4 marks)

(b) What are cut-backs? Differentiate between rapid, medium and slow curing cut-backs (4 marks)

(c) Emulsions refer to materials used in road construction
- (i) What are emulsions and where are they commonly used.
- (ii) Distinguish between cationic and anionic emulsions.
- (iii) List two advantages and two disadvantages of using bitumen emulsion in road construction (9 marks)

(d) Explain the use of pre-coated chipping carpets in road surfacing. State the advantages and disadvantages of a pre-coated chippings layer when compared with surface dressing (8 marks)



Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2010/2011

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 345 : CIVIL ENGINEERING MATERIALS II

DATE: FEBRUARY 17, 2011 TIME:11.15 A.M. – 1.15 P.M.

INSTRUCTIONS:

1. All questions carry equal marks.
2. Answer any THREE questions.

## QUESTION 1

a) Mineral aggregates can be obtained from either natural or artificial sources. Explain the manufacture of the following:
   i) Crushed limestone
   ii) Graded crushed stone
   iii) Gravel
   iv) Blast furnace slag

(10 marks)

b) i) What is cut-back bitumen? (4 marks)
   ii) Explain the following terms in relation to cut-back bitumen:
   - Rapid curving (RC)
   - Medium curving (MC)
   - Slow curving (SC)

(6 marks)

## QUESTION 2

a) Define two types of emulsions in common use. Also explain the action of emulsions. (8 marks)

b) Briefly describe how the following properties affect the quality of rock for road making:
   i) Mineral composition and decomposition
   ii) Grain size
   iii) Rock structure
   iv) Recrystallisation

(8 marks)

c) How does adhesion of bitumen affect road construction and performance? (4 marks)



## QUESTION 3

a) Briefly describe the penetration test, including a rough sketch, as done on bitumen. (6 marks)

b) Two bitumens have the same penetration of 85 at 25°C, but different softening points. One bitumen (A) has a ring-and-ball softening point of 54°C and the other (B) has a ring-and-ball softening point of 60°C. Plot the penetration/temperature charts for the two binders and calculate the Penetration Index (PI) of each. By extension of the graph, determine the Fraas Breaking point for each Bitumen.

Which of the two binders would you prefer for road construction? Explain.

(14 marks)

## QUESTION 4

A contractor on a road construction project in Makueni County plans to establish good borrow sites and quarries to provide materials for construction of the road surfacing, base and subbase. According to the pavement design provided by the CLIENT, the surfacing will comprise of asphalt concrete with a single seal surface treatment as wearing course, the base layer will be constructed of graded crushed stone while subbase will be made with cement-improved gravel.

The section traversed by the road is generally rocky, with rock outcrops prevalent at numerous locations near the proposed road alignment. Tests carried out on the alignment soils during design also suggest the presence of lateritic gravel (murram) although pockets of highly active black cotton soil have been noted along the section passing through the flat plains on the lower altitudes near Kaiti River. Sand is a common feature everywhere.

Explaining the reasons behind each test, discuss the tests you would propose to prove materials for surfacing base course, subbase and subgrade for technical compliance. (20 marks)



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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 345: CIVIL ENGINEERING MATERIALS II

DATE: FEBRUARY 2, 2012 TIME: 11.15 A.M. – 1.15 P.M.

INSTRUCTIONS

**Answer any THREE Questions.**
**All Questions carry EQUAL marks.**

## QUESTION 1

You have been appointed a materials Engineer for a road design project. You are required to conduct tests on materials for surfacing, road base and subbase. Traffic studies have been completed and it is anticipated that the pavement will be constructed of surface dressing over granular base and subbase comprising natural gravel.

(a) Describe the tests to be carried out on bitumen and aggregate chippings in order to specify their use in surface dressing.

(b) Describe the tests to be carried out on granular materials for base and subbase.

(c) How should the binder spray and chipping spread rates be controlled in the field during construction?

(25 Marks)

## QUESTION 2

(a) (i) Explain the use of pre-coated chipping carpets in road surfacing.

(ii) State the advantages and disadvantages of pre-colonial chippings when compared with surface dressing.

(8 Marks)

(b) Define surface dressing/treatment in road construction.

State three functions of surface dressing. (5 Marks)



(c) Calculate the rate of spread of bitumen in $kg/m^2$ and aggregates in $m^3/10m^2$ for surface dressing course 12 mm thick. The initial voids may be taken to be 50% and voids after final compaction by traffic assumed to be 20%. Whip-off due to traffic is 10%. Binder should form 60% of final voids.

Specific gravity of bitumen is 1.2. (12 Marks)

## QUESTION 3

(a) Define the following terms in road surfacing:

- Prime coats
- Tack coats

(4 Marks)

(b) What are cut-backs?

Differentiate between rapid, medium and slow caring cut-backs. (4 Marks)

(c) What are emulsions and where are they commonly used?

Distinguish between Cationic and anionic emulsions. Also list two advantages and two disadvantages of using bitumen emulsion in road construction.

(9 Marks)

(d) The bitumen samples A, and B, have the same penetration of 85 at 25°C but different softening points. A has a ring-and-ball softening point of 54°C while B has 60°C.

Plot the per-temperature charts for the two binders an calculate the Penetration Index (PI) of each. By extension of each graph, determine their Fraas breaking points. Which binder would you prefer for hot areas, why? (8 Marks)

## QUESTION 4

(a) What is asphalt Concrete?

State the advantages of asphalt concrete in road construction.

(b) Describe the basic properties and functions of the following components in a bituminous mixture:

- Coarse aggregates
- Fine aggregates
- Filter material
- Binder



Skani: Kwa hisani ya Eric

(c) A sample of Asphalt concrete (AC) cut from a completed road weighed 3680g in air and 2060g in water. Sieve analysis on aggregate recovered from the sample recorded the following grading:-

| Sieve size | % passing |
|---|---|
| 20 mm | 100 |
| 14 mm | 95 |
| 10 mm | 80 |
| 6 mm | 65 |
| 2 mm (rb. 7 BS) | 45 |
| 1 mm (No. 14 BS) | 35 |
| 0.425 mm (No. 36 BS) | 22 |
| 0.075 (No. 200 BS) | 10 |

The bitumen content for the mix was 7.5%.

The specific gravity of the aggregate were:

- Coarse -- 2.60
- Fine -- 2.65
- Filter -- 2.70

Using necessary computations, evaluate the mix for the degree of mixing and degree of compaction achieved in the field.

The specific gravity of bitumen in 1.04. (9 Marks)

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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2010/2011

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 331: STRENGTH OF MATERIAL

DATE: 15 FEBRUARY 2011 TIME: 11.15 A.M. – 1.15 P.M.

INSTRUCTIONS

Answer Number 1 and any 2 other Questions.

No. 1

(a) Define the term "buckling" in steel columns. (2 Marks)

(b) (i) From first principles, determine that "Eulers formula" for critical buckling load for a long column, is given by $P_{cr} = \frac{\pi^2 E I}{L^2}$. (15 Marks)

(ii) Show that the corresponding critical buckling stress is given by

$$F_c = \frac{\pi^2 E}{(L/r)^2}.$$ (3 Marks)

No. 2

(a) A 254 x 254 x 167 Universal column, 6 meters long is adopted in a steel frame.

Using Eulers formula,

(i) Determine that the column is within the elastic range if the potential limit is 350 N/mm$^2$ (7 Marks)

(ii) Determine the critical Buckling load. (2 Marks)



Data: Youngs Modulus E = 205 KN/mm$^2$
Use Universal Column Data from SDM sheet attached.

(b) (i) For the I-section 254 x 254 x 167 Universal Column, confirm if the section is plastic, compact or semi compact if it is a Rolled section (*Use Tables attached as well as Table II from BS59SC)

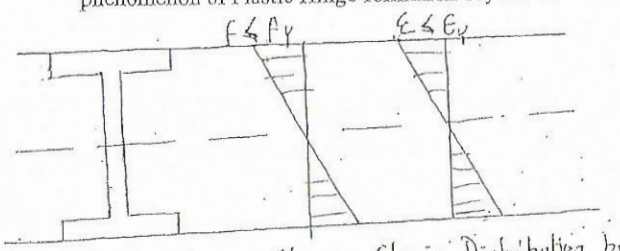
Data: $P_Y = 350$ N/mm$^2$ (5 Marks)

(ii) Describe short and intermediate steel column characteristics. (6 Marks)

No. 3

(a) Illustrate and explain (with a stress-strain graph) the characteristic "ductility of a steel section". (4 Marks)

(b) (i) For the idealized steel section below, illustrate and explain the phenomenon of Plastic Hinge formation beyond the elastic limit. (8 Marks)




Stress - Strain Distribution before Elastic Limit.

(ii) With the aid of a Moment-Rotation Graph sketch, describe slender, semi compact, compact and plastic sections in Structural Steel. (8 Marks)

No. 4

(a) Determine the Plastic Moment of Collapse ($M_p$) for the 2 beams below: (15 Marks)



Skani: Kwa hisani ya Eric

(b) The strut is made of steel 2.0m long and the angle section in Fig Q4B with the following section properties;
$A = 1915\ mm^2$, $I_{xx} = I_{yy} = 1.767E6mm^4$, $I_{uu} = 2.803E6mm^4$,

$I_{vv} = 0.730E6mm^4$.

Calculate the critical stress at buckling in $N/mm^2$. (6 marks)

5. The rectangular hollow section in Fig Q5 is subjected to the following forces Axial Force F = 108KN applied through the centroid $M_x$ = 12.3 KNm and a torsional moment T = 4.05 KNm.

(a) Calculate the combined longitudinal stress due to F and $M_x$ and the shear stress due to the twisting moment at A. (10 marks)

(b) Calculate the principal stress at A and the unit twist of the cross section. (10marks)





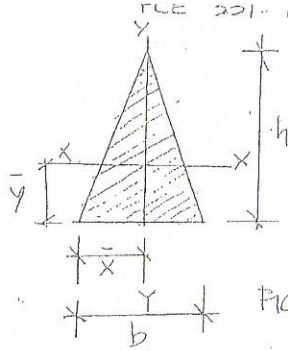



FIG Q1.

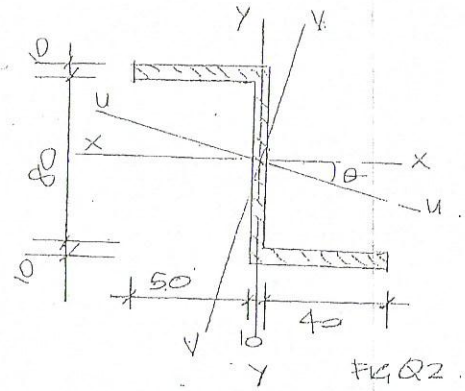



FIG Q2.

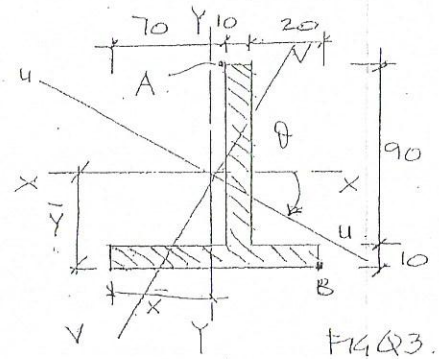



FIG Q3.

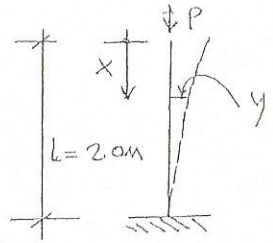



FIG Q4A.

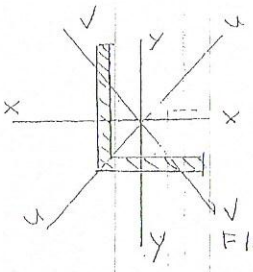
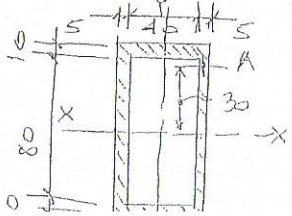



FIG Q4B.

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## UNIVERSAL COLUMNS

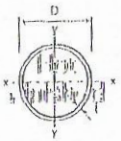
### PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter | Torsional Index | Warping Constant | Torsional Constant | Area of Section |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Axis x-x cm⁴ | Axis y-y cm⁴ | Axis x-x cm | Axis y-y cm | Axis x-x cm³ | Axis y-y cm³ | Axis x-x cm³ | Axis y-y cm³ | u | x | H dm⁶ | J cm⁴ | A cm² |
| 356 × 406 × 634 ǂ | 275000 | 98100 | 18.4 | 11.0 | 11600 | 1630 | 14200 | 7110 | 0.843 | 5.46 | 38.8 | 13700 | 808 |
| 356 × 406 × 551 ǂ | 227000 | 82700 | 18.0 | 10.9 | 9960 | 3950 | 12100 | 6060 | 0.841 | 6.05 | 31.1 | 9240 | 702 |
| 356 × 406 × 467 ǂ | 183000 | 67800 | 17.6 | 10.7 | 8380 | 3290 | 10000 | 5030 | 0.838 | 6.66 | 24.3 | 5810 | 595 |
| 356 × 406 × 393 ǂ | 147000 | 55400 | 17.1 | 10.5 | 7000 | 2720 | 8220 | 4150 | 0.837 | 7.87 | 18.8 | 3550 | 501 |
| 356 × 406 × 340 ǂ | 120000 | 46900 | 16.8 | 10.4 | 6030 | 2330 | 7000 | 3540 | 0.836 | 8.84 | 15.5 | 2340 | 433 |
| 356 × 406 × 287 ǂ | 99800 | 38700 | 16.5 | 10.3 | 5080 | 1940 | 5810 | 2950 | 0.834 | 10.2 | 12.3 | 1440 | 366 |
| 356 × 406 × 235 ǂ | 79100 | 31000 | 16.3 | 10.2 | 4150 | 1570 | 4690 | 2380 | 0.835 | 12.0 | 9.54 | 812 | 299 |
| 356 × 368 × 202 ǂ | 66300 | 23700 | 16.1 | 9.60 | 3540 | 1260 | 3970 | 1920 | 0.844 | 13.4 | 7.18 | 556 | 257 |
| 356 × 368 × 177 ǂ | 57100 | 20500 | 15.9 | 9.54 | 3100 | 1100 | 3460 | 1670 | 0.843 | 15.0 | 6.09 | 381 | 226 |
| 356 × 368 × 153 ǂ | 48600 | 17000 | 15.8 | 9.40 | 2680 | 918 | 2970 | 1440 | 0.844 | 17.0 | 5.11 | 251 | 195 |
| 356 × 368 × 129 ǂ | 40300 | 14000 | 15.6 | 9.43 | 2260 | 793 | 2480 | 1200 | 0.845 | 19.8 | 4.18 | 153 | 164 |
| 305 × 305 × 283 | 78000 | 24000 | 14.6 | 8.27 | 4320 | 1530 | 5110 | 2340 | 0.856 | 7.65 | 6.35 | 2030 | 360 |
| 305 × 305 × 240 | 64200 | 20300 | 14.5 | 8.15 | 3640 | 1280 | 4250 | 1950 | 0.854 | 8.74 | 5.03 | 1270 | 306 |
| 305 × 305 × 198 | 50900 | 16300 | 14.2 | 8.04 | 3000 | 1040 | 3440 | 1580 | 0.854 | 10.2 | 3.88 | 734 | 252 |
| 305 × 305 × 158 | 38600 | 12600 | 13.9 | 7.80 | 2370 | 808 | 2680 | 1230 | 0.852 | 12.5 | 2.87 | 378 | 201 |
| 305 × 305 × 137 | 32800 | 10700 | 13.7 | 7.83 | 2050 | 692 | 2300 | 1050 | 0.852 | 14.1 | 2.39 | 249 | 174 |
| 305 × 305 × 118 | 27700 | 9060 | 13.6 | 7.77 | 1780 | 599 | 1960 | 895 | 0.851 | 16.2 | 1.98 | 161 | 150 |
| 305 × 305 × 97 | 22300 | 7310 | 13.4 | 7.80 | 1450 | 479 | 1590 | 726 | 0.852 | 19.2 | 1.56 | 91.2 | 123 |
| 254 × 254 × 167 | 30000 | 9870 | 11.9 | 8.61 | 2080 | 744 | 2420 | 1140 | 0.861 | 8.50 | 1.83 | 828 | 213 |
| 254 × 254 × 132 | 22500 | 7500 | 11.8 | 8.09 | 1630 | 576 | 1870 | 878 | 0.860 | 10.3 | 1.19 | 319 | 168 |
| 254 × 254 × 107 | 17500 | 5930 | 11.3 | 8.59 | 1310 | 458 | 1480 | 697 | 0.849 | 12.4 | 0.898 | 172 | 136 |
| 254 × 254 × 89 | 14000 | 4800 | 11.2 | 8.55 | 1100 | 379 | 1220 | 575 | 0.851 | 14.5 | 0.717 | 102 | 113 |
| 254 × 254 × 73 | 11400 | 3910 | 11.1 | 8.46 | 898 | 307 | 992 | 465 | 0.849 | 17.3 | 0.582 | 57.6 | 93.1 |
| 203 × 203 × 86 | 9450 | 3130 | 9.28 | 5.34 | 850 | 299 | 977 | 458 | 0.849 | 10.2 | 0.318 | 137 | 110 |
| 203 × 203 × 71 | 7620 | 2540 | 9.10 | 5.30 | 706 | 249 | 799 | 374 | 0.853 | 11.9 | 0.250 | 80.2 | 90.4 |
| 203 × 203 × 60 | 6130 | 2070 | 8.96 | 5.20 | 584 | 201 | 658 | 305 | 0.848 | 14.1 | 0.197 | 47.2 | 76.4 |
| 203 × 203 × 52 | 5260 | 1780 | 8.91 | 5.18 | 510 | 174 | 567 | 264 | 0.848 | 15.8 | 0.167 | 31.8 | 66.3 |
| 203 × 203 × 46 | 4570 | 1550 | 8.82 | 5.13 | 450 | 152 | 497 | 231 | 0.846 | 17.7 | 0.143 | 22.2 | 58.7 |
| 152 × 152 × 37 | 2210 | 706 | 6.85 | 3.87 | 273 | 91.5 | 309 | 140 | 0.849 | 13.3 | 0.0309 | 19.2 | 47.1 |
| 152 × 152 × 30 | 1750 | 560 | 6.78 | 3.83 | 222 | 73.3 | 248 | 112 | 0.849 | 16.0 | 0.0308 | 10.5 | 38.3 |
| 152 × 152 × 23 | 1250 | 400 | 6.54 | 3.70 | 164 | 52.8 | 182 | 80.2 | 0.840 | 20.7 | 0.0212 | 4.83 | 29.2 |

ǂ Check availability.



## HOT-FINISHED CIRCULAR HOLLOW SECTIONS




### DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Build for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outside Diameter D mm | Thickness t mm | kg/m | A cm² | DB | I cm⁴ | r cm | Z cm³ | S cm³ | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² |
| 219.1 | 5.0 ~ | 26.4 | 33.6 | 43.8 | 1930 | 7.57 | 176 | 229 | 3860 | 352 | 0.688 | 26.1 |
| | 6.3 ~ | 33.1 | 42.1 | 34.8 | 2390 | 7.53 | 218 | 285 | 4770 | 436 | 0.688 | 20.8 |
| | 8.0 ~ | 41.6 | 53.1 | 27.4 | 2960 | 7.47 | 270 | 357 | 5920 | 540 | 0.688 | 16.5 |
| | 10.0 ~ | 51.8 | 65.7 | 21.9 | 3600 | 7.40 | 328 | 436 | 7200 | 657 | 0.688 | 13.3 |
| | 12.5 ~ | 63.7 | 81.1 | 17.5 | 4350 | 7.32 | 397 | 534 | 8690 | 793 | 0.688 | 10.8 |
| 244.5 | 12.0 ~ | 68.8 | 87.7 | 20.4 | 5840 | 8.23 | 480 | 649 | 11900 | 972 | 0.768 | 11.2 |
| 273.0 | 5.0 ~ | 33.0 | 42.1 | 54.6 | 3780 | 9.48 | 277 | 359 | 7560 | 554 | 0.858 | 26.0 |
| | 6.3 | 41.4 | 52.8 | 43.3 | 4700 | 9.43 | 344 | 446 | 9390 | 688 | 0.858 | 20.7 |
| | 8.0 ~ | 52.3 | 66.6 | 34.1 | 5850 | 9.37 | 429 | 562 | 11700 | 857 | 0.858 | 16.4 |
| | 10.0 | 64.9 | 82.6 | 27.3 | 7150 | 9.31 | 524 | 692 | 14300 | 1050 | 0.858 | 13.2 |
| | 12.5 | 80.3 | 102 | 21.8 | 8700 | 9.22 | 637 | 849 | 17400 | 1270 | 0.858 | 10.7 |
| | 16.0 ~ | 101 | 129 | 17.1 | 10700 | 9.10 | 784 | 1060 | 21400 | 1570 | 0.858 | 8.48 |
| 323.9 | 6.3 ~ | 49.3 | 62.9 | 51.4 | 7930 | 11.2 | 490 | 636 | 15900 | 979 | 1.02 | 20.7 |
| | 8.0 ~ | 62.0 | 79.4 | 40.5 | 9910 | 11.2 | 612 | 799 | 19800 | 1220 | 1.02 | 16.4 |
| | 10.0 ~ | 77.4 | 98.6 | 32.4 | 12200 | 11.1 | 751 | 986 | 24300 | 1500 | 1.02 | 13.2 |
| | 12.5 ~ | 96.0 | 122 | 25.9 | 14800 | 11.0 | 917 | 1210 | 29700 | 1800 | 1.02 | 10.6 |
| | 16.0 | 122 | 155 | 20.2 | 18400 | 10.9 | 1140 | 1520 | 36800 | 2270 | 1.02 | 8.40 |
| 406.4 | 6.3 ~ | 62.2 | 79.2 | 64.5 | 15900 | 14.1 | 780 | 1010 | 31700 | 1560 | 1.28 | 20.6 |
| | 8.0 ~ | 78.6 | 100 | 50.8 | 19900 | 14.1 | 978 | 1270 | 39700 | 1960 | 1.28 | 16.3 |
| | 10.0 ~ | 97.8 | 125 | 40.6 | 24500 | 14.0 | 1210 | 1570 | 49000 | 2410 | 1.28 | 13.1 |
| | 12.5 ~ | 121 | 155 | 32.5 | 30000 | 13.9 | 1480 | 1940 | 60100 | 2900 | 1.28 | 10.5 |
| | 16.0 | 154 | 196 | 25.4 | 37500 | 13.8 | 1840 | 2440 | 74900 | 3600 | 1.28 | 8.31 |
| 457.0 | 8.0 ~ | 88.6 | 113 | 57.1 | 28500 | 15.9 | 1250 | 1610 | 56900 | 2400 | 1.44 | 16.3 |
| | 10.0 ~ | 110 | 140 | 45.7 | 35100 | 15.8 | 1540 | 2000 | 70200 | 3070 | 1.44 | 13.1 |
| | 12.5 ~ | 137 | 175 | 36.6 | 43100 | 15.7 | 1890 | 2470 | 86300 | 3780 | 1.44 | 10.5 |
| | 16.0 | 174 | 222 | 28.6 | 54000 | 15.6 | 2360 | 3110 | 108000 | 4730 | 1.44 | 8.28 |
| 508.0 | 8.0 ~ | 98.6 | 126 | 63.5 | 39300 | 17.7 | 1550 | 2000 | 78600 | 3000 | 1.60 | 16.2 |
| | 10.0 ~ | 123 | 156 | 50.8 | 48500 | 17.6 | 1910 | 2480 | 97000 | 3820 | 1.60 | 13.0 |
| | 12.5 | 153 | 195 | 40.6 | 60000 | 17.5 | 2350 | 3070 | 120000 | 4710 | 1.60 | 10.5 |
| | 16.0 ~ | 194 | 247 | 31.8 | 74900 | 17.4 | 2950 | 3870 | 150000 | 5900 | 1.60 | 8.25 |
| | 20.0 ~ | 241 | 307 | 25.4 | 91400 | 17.3 | 3600 | 4770 | 183000 | 7200 | 1.60 | 6.64 |

Check availability in S275.

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(b) (i) What assumptions form the basis of the Bernoulli theory of pure bending? (2 Marks)

(ii) With the aid of a sketch, illustrate why beams and columns are haunched in portal frames. (2 Marks)

(iii) What are 2 causes of Residual Stresses that remain in a steel member section after it has been formed? (1 Mark)

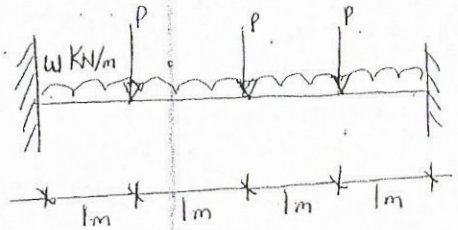
**No. 5**

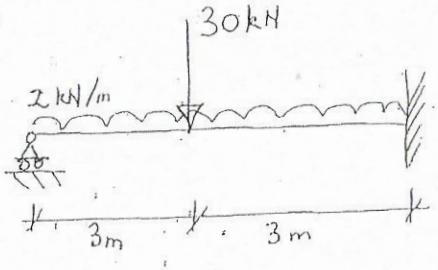
(a) (i) Illustrate 4 factors that affect properties of timber. (8 Marks)

(ii) Describe briefly 3 design methods for Structural Timber. (9 Marks)

(b) Illustrate the use of Timber spaced columns. (3 Marks)

(a)

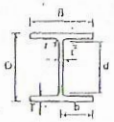


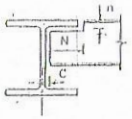








## UNIVERSAL COLUMNS




### DIMENSIONS

| Section Designation | Mass per Metre | Depth of Section | Width of Section | Thickness: Web | Thickness: Flange | Root Radius | Depth between Fillets | Ratios for Local Buckling: Flange | Ratios for Local Buckling: Web | Dimensions for Detailing: End Clearance | Dimensions for Detailing: Notch | | Surface Area: Per Metre | Surface Area: Per Tonne |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m | D mm | B mm | t mm | T mm | r mm | d mm | b/T | d/t | C mm | N mm | n mm | m² | m² |
| 356 × 406 × 634 ǂ | 633.9 | 474.6 | 424.0 | 47.6 | 77.0 | 15.2 | 290.2 | 2.75 | 6.10 | 26 | 200 | 94 | 2.52 | 3.98 |
| 356 × 406 × 551 ǂ | 551.0 | 455.6 | 418.5 | 42.1 | 67.5 | 15.2 | 290.2 | 3.10 | 6.89 | 23 | 200 | 84 | 2.47 | 4.49 |
| 356 × 406 × 467 ǂ | 467.0 | 436.6 | 412.2 | 35.8 | 58.0 | 15.2 | 290.2 | 3.55 | 8.11 | 20 | 200 | 74 | 2.42 | 5.19 |
| 356 × 406 × 393 ǂ | 393.0 | 419.0 | 407.0 | 30.6 | 49.2 | 15.2 | 290.2 | 4.14 | 9.48 | 17 | 200 | 68 | 2.38 | 6.05 |
| 356 × 406 × 340 ǂ | 339.9 | 406.4 | 403.0 | 26.6 | 42.9 | 15.2 | 290.2 | 4.70 | 10.9 | 15 | 200 | 60 | 2.35 | 6.90 |
| 356 × 406 × 287 ǂ | 287.1 | 393.8 | 399.0 | 22.6 | 36.5 | 15.2 | 290.2 | 5.47 | 12.8 | 13 | 200 | 52 | 2.31 | 8.05 |
| 356 × 406 × 235 ǂ | 235.1 | 381.0 | 394.8 | 18.4 | 30.2 | 15.2 | 290.2 | 6.54 | 15.8 | 11 | 200 | 46 | 2.28 | 9.69 |
| 356 × 368 × 202 ǂ | 201.9 | 374.6 | 374.7 | 16.5 | 27.0 | 15.2 | 290.2 | 6.94 | 17.6 | 10 | 190 | 44 | 2.19 | 10.8 |
| 356 × 368 × 177 ǂ | 177.0 | 368.2 | 372.6 | 14.4 | 23.8 | 15.2 | 290.2 | 7.83 | 20.2 | 9 | 190 | 40 | 2.17 | 12.3 |
| 356 × 368 × 153 ǂ | 152.0 | 362.0 | 370.5 | 12.3 | 20.7 | 15.2 | 290.2 | 8.95 | 23.6 | 8 | 190 | 36 | 2.16 | 14.1 |
| 356 × 368 × 129 ǂ | 129.0 | 355.6 | 368.6 | 10.4 | 17.5 | 15.2 | 290.2 | 10.50 | 27.9 | 7 | 190 | 34 | 2.14 | 16.6 |
| 305 × 305 × 283 | 282.9 | 365.3 | 322.2 | 26.8 | 44.1 | 15.2 | 246.7 | 3.65 | 9.21 | 15 | 158 | 60 | 1.94 | 6.86 |
| 305 × 305 × 240 | 240.0 | 352.5 | 318.4 | 23.0 | 37.7 | 15.2 | 246.7 | 4.22 | 10.7 | 14 | 158 | 54 | 1.91 | 7.94 |
| 305 × 305 × 198 | 198.1 | 339.9 | 314.5 | 19.1 | 31.4 | 15.2 | 246.7 | 5.01 | 12.9 | 12 | 158 | 48 | 1.87 | 9.46 |
| 305 × 305 × 158 | 158.1 | 327.1 | 311.2 | 15.8 | 25.0 | 15.2 | 246.7 | 6.22 | 15.6 | 10 | 158 | 42 | 1.84 | 11.6 |
| 305 × 305 × 137 | 136.9 | 320.5 | 309.2 | 13.8 | 21.7 | 15.2 | 246.7 | 7.12 | 17.9 | 9 | 158 | 38 | 1.82 | 13.3 |
| 305 × 305 × 118 | 117.9 | 314.5 | 307.4 | 12.0 | 18.7 | 15.2 | 246.7 | 8.22 | 20.6 | 8 | 158 | 34 | 1.81 | 15.3 |
| 305 × 305 × 97 | 96.9 | 307.9 | 305.3 | 9.9 | 15.4 | 15.2 | 246.7 | 9.91 | 24.9 | 7 | 158 | 32 | 1.79 | 18.5 |
| 254 × 254 × 167 | 167.1 | 289.1 | 265.2 | 19.2 | 31.7 | 12.7 | 200.3 | 4.18 | 10.4 | 12 | 134 | 46 | 1.58 | 9.45 |
| 254 × 254 × 132 | 132.0 | 276.3 | 261.3 | 15.3 | 25.3 | 12.7 | 200.3 | 5.16 | 13.1 | 10 | 134 | 38 | 1.55 | 11.7 |
| 254 × 254 × 107 | 107.1 | 266.7 | 258.8 | 12.8 | 20.5 | 12.7 | 200.3 | 6.31 | 15.6 | 8 | 134 | 34 | 1.52 | 14.2 |
| 254 × 254 × 89 | 88.9 | 260.3 | 256.3 | 10.3 | 17.3 | 12.7 | 200.3 | 7.41 | 19.4 | 7 | 134 | 30 | 1.50 | 16.9 |
| 254 × 254 × 73 | 73.1 | 254.1 | 254.6 | 8.6 | 14.2 | 12.7 | 200.3 | 8.96 | 23.3 | 6 | 134 | 26 | 1.49 | 20.4 |
| 203 × 203 × 86 | 86.1 | 222.2 | 209.1 | 12.7 | 20.5 | 10.2 | 160.8 | 5.10 | 12.7 | 8 | 110 | 32 | 1.24 | 14.4 |
| 203 × 203 × 71 | 71.0 | 215.8 | 206.4 | 10.0 | 17.3 | 10.2 | 160.8 | 5.97 | 16.1 | 7 | 110 | 28 | 1.22 | 17.2 |
| 203 × 203 × 60 | 60.0 | 209.6 | 205.8 | 9.4 | 14.2 | 10.2 | 160.8 | 7.25 | 17.1 | 7 | 110 | 28 | 1.21 | 20.1 |
| 203 × 203 × 52 | 52.0 | 206.2 | 204.3 | 7.9 | 12.5 | 10.2 | 160.8 | 8.17 | 20.4 | 6 | 110 | 24 | 1.20 | 23.0 |
| 203 × 203 × 46 | 46.1 | 203.2 | 203.6 | 7.2 | 11.0 | 10.2 | 160.8 | 9.25 | 22.3 | 6 | 110 | 22 | 1.19 | 25.8 |
| 152 × 152 × 37 | 37.0 | 161.8 | 154.4 | 8.0 | 11.5 | 7.6 | 123.6 | 6.71 | 15.5 | 6 | 84 | 20 | 0.912 | 24.7 |
| 152 × 152 × 30 | 30.0 | 157.6 | 152.9 | 6.5 | 9.4 | 7.6 | 123.6 | 8.13 | 19.0 | 5 | 84 | 18 | 0.901 | 30.0 |
| 152 × 152 × 23 | 23.0 | 152.4 | 152.2 | 5.8 | 6.8 | 7.6 | 123.6 | 11.2 | 21.3 | 5 | 84 | 16 | 0.889 | 38.7 |

ǂ Check availability.

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# UNIVERSITY OF NAIROBI

**FIRST SEMESTER EXAMINATIONS 2009/2010**

**THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING**

**FCE 331 : STRENGTH OF MATERIALS II**

**DATE: 16 FEBRUARY, 2010** **TIME: 11.15 A.M. – 1.15 P.M.**

**INSTRUCTIONS**

i) Attempt ANY THREE questions.
ii) All questions carry equal marks.
iii) Non programmable electronic calculators can be used.
iv) Cell-phones must not be operated in the examination room

Q.1.i) Explain how carbon controls the properties of steel? (5 marks)
ii) What is the difference between cast iron and mild steel? (6 marks)
iii) Explain the role of the following elements used in the blast furnace extraction of iron from its ore.

a) Coke (6⅓ marks)
b) Lime (6 marks)

Q.2.i) Explain the difference between a slender column and a stocky column. (3 marks)

ii) How can one tell that a column is too stiff to comply with Euler theory? (2 marks)

iii) A tube of internal diameter 50 mm is made of two elements 'a' and 'b' as shown in Figure Q.2. Each element is 2 mm thick and have the following moduli of elasticity

$E_a = 150 kN/mm^2$
$E_b = 200 kN/mm^2$

the yield stresses of the two elements are

$\sigma_{ya} = 100 N/mm^2$
$\sigma_{yb} = 175 N/mm^2$

If the tube is stiff enough to fail by material yield without buckling when loaded in axial compression, determine the failure load. (18⅓ marks)

Q.3. A steel I-section is used as a beam as shown in Figure Q.3. The beam has the following material and section properties:

| | |
|---|---|
| Modulus of elasticity, | $E = 210 kN/mm^2$ |
| Yield stress, | $\sigma_y = 250 N/mm^2$ |
| Second moment of area about Y-Y axis, | $I_y = 1{,}230{,}000 mm^4$ |



| | |
|---|---|
| Second moment of area about x-x axis, | $I_x = 44{,}600{,}000 mm^4$ |
| Torsional constant, | $J = 47{,}700 mm^4$ |
| Overall depth, | $D = 305 mm$ |
| Depth of web between fillets, | $d = 276 mm$ |
| Thickness of web, | $t = 5.8 mm$ |
| Poisson's ratio, | $\nu = 0.3$ |

The beam carries a concentrated load 'P' at mid-span of the beam with a contact leng 300 mm. The ends of the beam are restrained against rotation.

i) Determine the value of 'P' that will cause the buckling of the top flange of the beam when the beam span s 2.30 m. (11⅓ mark
ii) Establish whether the load that will cause the buckling of the top flange of the beam will also cause the buckling of the web. (12 marks)

Q.4. i) What are the main causes of deterioration of timber? Explain briefly how the effects can be mitigated? (6 marks)

ii) A solid timber section has cross-section dimensions of 150mm x 50mm. It is used as a strut with a clear height of 2.40m. The lower end of the strut is built while the upper end is fixed in position but is free to rotate. The timber has th following material properties:
Modulus of elasticity, $E = 3{,}600 N/mm^2$
Yield stress in axial compression, $\sigma_c = 6 N/mm^2$
Determine the load at which the strut will fail in axial compression. (17⅓ mar

Q.5. i) What is a composite material? (3 marks)
ii) What is a transformed section? (3 marks)

iii) The composite section shown in Figure Q.5 consists of timber of width 50mm depth 150mm, reinforced with two 2mm thick plates on each vertical side. Th moduli of elasticity are:
Steel $E_s = 200 kN/mm^2$
Timber $E_t = 4 kN/mm^2$
and the yield stresses are:
Steel $\sigma_{sy} = 275 N/mm^2$
Timber $\sigma_{ty} = 7 N/mm^2$

a) Transform the section to an equivalent timber section. (9⅓ marks)
b) Determine the maximum bending moment that the section can carry. (8 marks)



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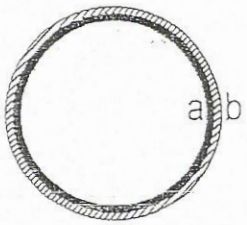


FIGURE Q2

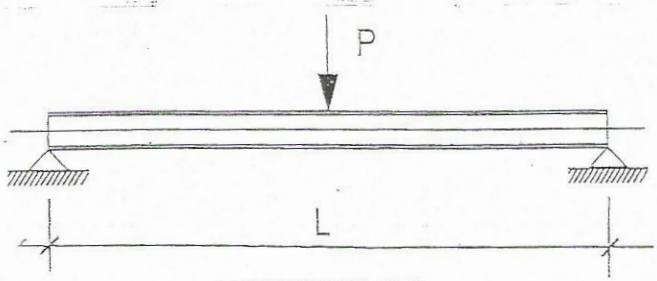


FIGURE Q3

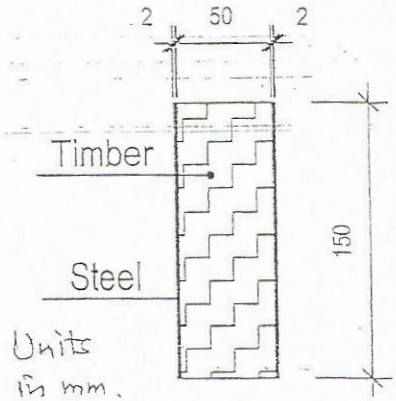


FIGURE Q5



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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

FCE 351: ENGINEERING SURVEYING II

DATE: FEBRUARY 3, 2012 TIME: 11.15 A.M. – 1.15 P.M

INSTRUCTIONS

Answer any three questions.

## QUESTION ONE (20 marks)

(a) The following readings were taken onto a vertical staff, from an instrument station X, from a theodolite with a multiplying constant of 100. Using the data on Table 1 and given that the height of instrument at X is 1.67 m and the reduced level of X is 890.68 m, determine:-

(i) The reduced levels of H and K

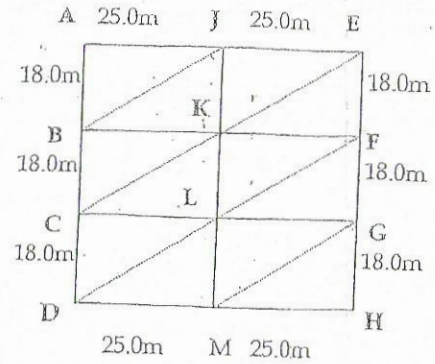
(ii) The gradient between H and K

Table 1

| Staff Station | Horizontal Reading | Stadia Readings (m) | Vertical Angle |
|---|---|---|---|
| H | 37° 30′ | 1.230, 1.720, 2.210 | + 6° 48′ |
| K | 92° 50′ | 1.764, 2.328, 2.892 | - 8° 25′ |

(b) Heights were determined for twelve grid intersections at a building to enable a contractor to estimate the volume of material to be excavated. If the formation level of the building is to be 1015.00m, calculate the volume of material to be excavated, if the site is divided up into triangle, as shown on Figure 1.

*Figure 1*




*Reduced levels at grid corners (m)*

| | |
|---|---|
| A = 1018.20 | G = 1016.28 |
| B = 1015.42 | H = 1017.00 |
| C = 1017.13 | J = 1016.09 |
| D = 1017.51 | K = 1015.58 |
| E = 1018.74 | L = 1016.27 |
| F = 1015.35 | M = 1018.86 |

## QUESTION TWO (20 marks)

(a) Determine the side widths and areas of the following cross sections:-

(i) Fill section

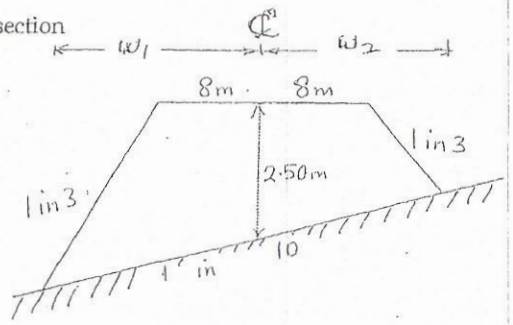



*Diagram 1*

*(5 marks)*

(ii) Cut section

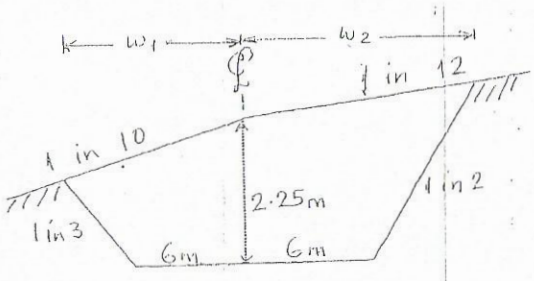



*Diagram 2*

*(5 marks)*



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(b) Given the following cross sectional areas (as shown on Table 2), determine the volume of material between sections A1 and A6, using the Prismoidal formula. The distance between consecutive cross section in 20m.

*Table 2*

| Cross section | A1 | A2 | A3 | A4 | A5 | A6 |
|---|---|---|---|---|---|---|
| Area enclosed ($m^2$) | 52.78 | 64.13 | 78.90 | 67.20 | 74.18 | 85.32 |

*(10 marks)*

QUESTION THREE (20 marks)

(a) The following readings were taken from two different level stations (H and K) onto two staff stations A and B.

| | To staff at A | To staff at B |
|---|---|---|
| From H | 2.054 m | 2.897m |
| From K | 3.345m | 4.190m |

Determine the difference in elevation between A and B. (4 marks)

(b) Reduce the following levelling observations and determine the reduced levels of various staff stations, given that the reduced level of TERA is 890.300m above Mean Sea Level.

From A: To benchmark TERA and staff stations D1, D2 and D3 readings 2.654, 2.353m, 2.281m and 1.750m were obtained respectively.

From B. To D3, D5, D6, D7 and D8 readings 2.123m, -1.926m, -1.786m, 1.753m and 1.962m were obtained respectively.

From C. To D8, D9, D4 and D10 readings 2.324m, 1.827m, 1.713m and 1.534m were obtained respectively. (10 marks)

(c) A slope of 1 in 100 is to be maintained between invert levels at D3 and D4, which are 120.00m apart, for a sewer that is to be constructed with invert level at D4 at a higher elevation than that at D3. If the invert level at D3 is 888.800m, determine the height of sight rails, above ground, at D3 and D4 if a boning rod, 3.50m long. is to be used during construction. (6 marks)



QUESTION FOUR (20 marks)

(a) Explain about the information that may be obtained by plotting the mass-haul diagram directly below the longitudinal section of a centre line of a proposed grade of a road or railway construction. (5 marks)

(b) Discuss the main precautions that are taken in Precise Levelling. (5 marks)

(c) Identify the circumstances under which it may be necessary to carry out reciprocal levelling and mention errors that are minimised by the procedure. (5 marks)

(d) Discuss briefly the application of lasers in setting out works in Civil Engineering. (5 marks)

QUESTION FIVE (20 marks)

(a) Explain briefly why the closed traverse is regarded as more suitable for provision of control than the ray trace traverse. (4 marks)

(b) Using the following data, compute the coordinates of various control points in the traverse. Use the Bowditch method to distribute the misclosure.

| Station | Observations | Station | Observations |
|---|---|---|---|
| At Tr 22 | | At Tr 12 | |
| Tr 15 | 83° 02′ 35″ | Tr 16 | 81° 37′ 45″ |
| Tr 14 | 263° 52′ 59″ | Tr 18 | 348° 52′ 42″ |
| Tr 11 | 170° 11′ 37″ | | |
| At Tr 11 | | At Tr 18 | |
| Tr 22 | 350° 11′ 37″ | Tr 12 | 168° 52′ 34″ |
| Tr 16 | 261° 34′ 04″ | Tr 14 | 89° 09′ 50″ |
| | | Tr 17 | 351° 53′ 46″ |
| At Tr 16 | | | |
| Tr 11 | 81° 34′ 04″ | | |
| Tr 12 | 261° 37′ 39″ | | |

**Traverse distances:**
Tr 22 – Tr 11: 184.618m
Tr 11 – Tr 16: 157.456m
Tr 16 – Tr 12: 154.764m
Tr 12 – Tr 18: 212.277m

**Datum bearings**
Tr 22 – Tr 15: 83° 04′ 42″
Tr 22 – Tr 14: 263° 55′ 00″
Tr 18 – Tr 14: 89° 11′ 42″
Tr 18 – Tr 17: 351° 55′ 48″

**Datum coordinates:**

| Station | N (metres) | E |
|---|---|---|
| Tr 22 | - 19 382.71 | 34 857.26 |
| Tr 18 | - 19 401.78 | 34 538.87 |

*(16 marks)*

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# UNIVERSITY OF NAIROBI

**FIRST SEMESTER EXAMINATIONS 2010/2011**

**THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING**

**FCE 351: ENGINEERING SURVEYING II**

**DATE: 18 FEBRUARY 2011** **TIME: 11.15 A.M. – 1.15 P.M.**

**INSTRUCTIONS**

**Answer any THREE questions.**

**Question One (20 Marks)**

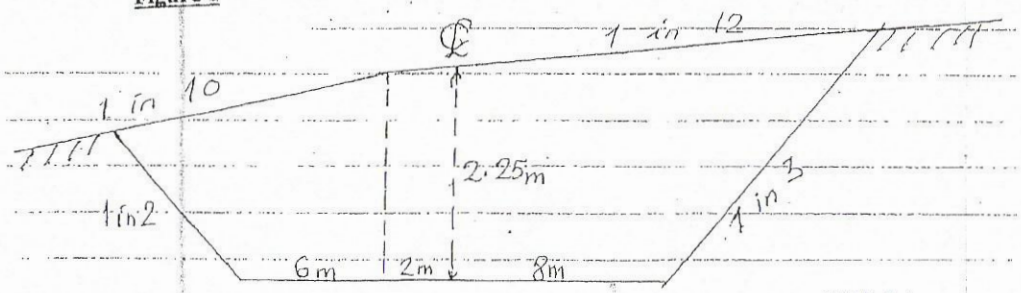
(a) Explain briefly the following terms as they are used in connection with mass-haul diagrams and indicate their relevance in road construction projects.

(i) Haul
(ii) Limit of economic haul
(iii) Bulking and shrinkage
(iv) Borrow

(6 Marks)

(b) Calculate the sidewidths and area of the cross-section on Figure 1.

**Figure 1**




(8 Marks)



(c) volume of material between sections A and F, using the Prismoidal formula. T
distance between consecutive cross sections is 25 m.

Table 1

| Cross Section | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Area enclosed ($m^2$) | 42.75 | 58.92 | 79.36 | 85.13 | 77.36 | 68. |

(6 Marks)

**Question Two (20 Marks)**

(a) Explain the circumstances under which it may be necessary to carry out recipro
leveling and mention errors that are minimized by that process. (4 Marks)

(b) The following readings were taken from two different stations (X and Y) onto
staff stations D and E.

| | To Staff at D | To Staff at E |
|---|---|---|
| From X | 1.954m | 2.385m |
| From Y | 2.752m | 3.186m |

Determine the difference in elevation between D and E. (4 Marks)

(c) Reduce the following observations and determine the reduced levels of variou
staff stations, given that the reduced level of ABDI is 575.000m above Mean S
Level.

From X: To benchmark ABDI and staff stations F1, F2 and W2 readings
2.534m, 2.423m, 2.018m and 1.828m were obtained respective

From Y: To W2, F4, W5, F6 and F3 readings 2.005m, -1.842m, -1.687m
1.573m and 1.926 m were obtained respectively.

From Z: To F3, F8, W4 and F10 readings 2.231m, 1.792m, 1.632m and
1.435m were obtained respectively.

(8 Marks)

(d) A slope of 1 in 100 is to be maintained between staff stations W2 and W4, wh
are 120m apart, for a sewer that is to be constructed with the invert level at W
a higher elevation than that at W2. If the invert level at W2 is 573.500m,
determine the height of sight rails, above ground, at W2 and W4 if a boning ro
3.00m long, is to be used during construction (4 Marks)



Skani: Kwa hisani ya Eric

## Question Three (20 Marks)

Make brief comments on the following:-

(a) How development in survey instrumentation has influenced methods that are used for establishment of survey control networks.

(b) Direct and indirect methods that are used for contouring on site plans.

(c) The main sources of error in distance measurement using electromagnetic distance measuring equipment.

(d) The effect of Curvature on determination of volumes of earthworks.

(5 Marks each)

## Question Four (20 Marks)

(a) The following readings were taken onto a vertical staff, from an instrument station X, from a theodolite with a multiplying constant of 100. Using the data on Table 2 and given that the height of the instrument at X is 1.67m and the reduced level of X is 890.68m determine:-

(i) The reduced levels of H and K

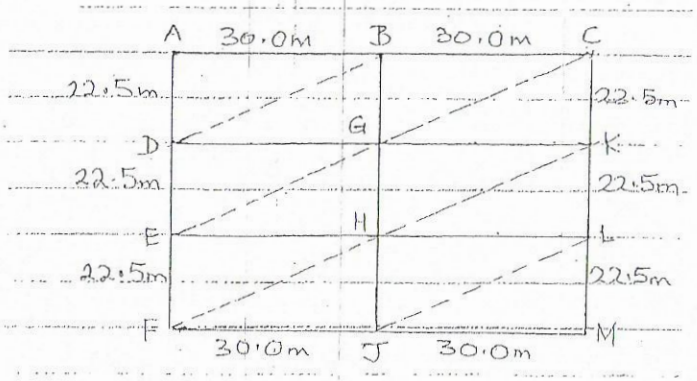
(ii) The gradient between H and K

**Table 2**

| Staff Station | Horizontal Reading | Stadia Readings (m) | Vertical Angle |
|---|---|---|---|
| H | 37° 30' | 1.230, 1.720, 2.210 | +6° 48' |
| K | 92° 50' | 1.764, 2.328, 2.892 | -8° 25' |

(10 Marks)

(b) Heights were determined for twelve grid intersections at a building site to enable a contractor to estimate the volume of material to be excavated. If the formation level of the building is to be 672.00 m, calculate the volume of material to be excavated, if the site is divided up into triangles as shown on Figure 2.






**Reduced levels at grid corners (m)**

| | | | | | |
|---|---|---|---|---|---|
| A | = | 678.25 | G | = | 681.27 |
| B | = | 682.47 | H | = | 687.01 |
| C | = | 677.13 | J | = | 676.04 |
| D | = | 677.52 | K | = | 682.27 |
| E | = | 680.75 | L | = | 686.29 |
| F | = | 675.36 | M | = | 683.85 |

(10 Marks)

## Question Five (20 Marks)

(a) Make brief comments on the statement that "……the ray trace is not as suitable as the closed traverse for provision of control" – noting that in practice a number of basic assumptions are made when a ray trace is used as a method for provision of horizontal control. (4 Marks)

(b) Using the data given below, compute coordinates of various control points in the following traverse using the Bowditch method to distribute the misclosure.

| Station | Observations | Station | Observations |
|---|---|---|---|
| At Tr9 | | At Tr 12 | |
| Tr8 | 319° 24' 02" | Tr 11 | 246° 44' 12" |
| Tr10 | 94° 17' 36" | Tr 14 | 37' 59' 09" |
| Tr12 | 202° 39' 03" | | |
| | | At Tr 14 | |
| At Tr10 | | Tr12 | 217° 59' 03" |
| Tr9 | 274° 17' 35" | Tr1 | 50° 32' 40" |
| Tr11 | 111° 48' 47" | | |
| | | At Tr1 | |
| At Tr11 | | Tr 14 | 230° 32' 42" |
| Tr10 | 291° 48' 42" | Tr 2 | 336° 24' 03" |
| Tr12 | 66° 44' 09" | Rg 3 | 136° 19' 01" |

**Traverse Distances**

Tr 9 – Tr 10: 115.076m
Tr 10 – Tr 11: 124.382m
Tr 11 – Tr 12: 107.985m
Tr 12 – Tr 14: 141.672m
Tr 14 – Tr 1: 123.516m

**Datum Bearings**

Tr 9 – Tr 8: 319° 23' 50"
Tr 9 – Tr 12: 202° 38' 50"
Tr 1 – Tr 2: 336° 23' 15"
Tr 1 – Rg 3: 136° 18' 13"

**Datum Coordinates**

| Station | N | (m) | E |
|---|---|---|---|
| Tr9 | -97 835.61 | | 35 733.25 |
| Tr1 | -97 652.63 | | 36 245.17 |

(16 Marks)

********



Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 351: ENGINEERING SURVEYING II

DATE: 19 FEBRUARY, 2010 TIME: 11.15 A.M. – 1.15 P.M

INSTRUCTIONS: Answer any THREE questions.

QUESTION ONE (20 marks)

(a). (i) Explain the circumstances under which it may be necessary to carry out reciprocal levelling and mention errors that are minimized by that procedure.

(ii) The following readings were taken from two different level stations (D and E) onto two staves at stations X and Y.

| | From station D | From station E |
|---|---|---|
| Staff station X | 1.892m | 2.219m |
| Staff station Y | 2.324m | 2.659m |

Determine the difference in elevation between X and Y. (6 marks)

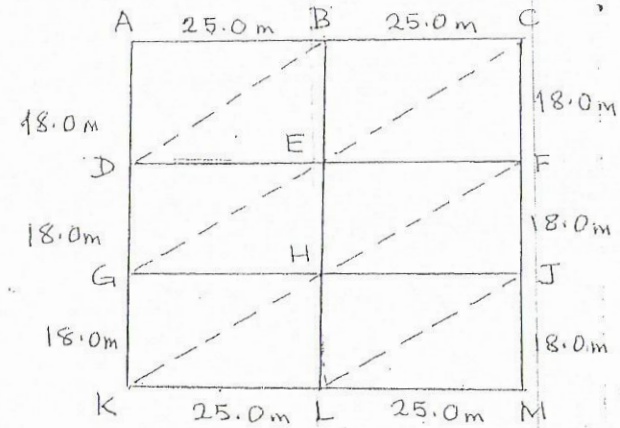
(b) The following readings were taken from an instrument station P onto a vertical staff, held at stations M and N. The height of instrument was 1.59m and the reduced level of the instrument station was 836.50m. If the multiplying constant of the instrument (theodolite) is 100, determine:

(i) The reduced levels of M and N.
(ii) The gradient between M and N.

| Staff Station | Horizontal Readings(m) | Stadia Readings (m) | Vertical Angle |
|---|---|---|---|
| M | 135° 45' | 2.028,2.586,3.144 | +6° 40' |
| N | 184° 10" | 1.856,2.838, 3.820 | -4° 25' |

(7 marks)

(c) Spot heights were taken at grid intersections at a small site at which a high-rise buil is to be constructed (as shown on Diagram 1). Using the data given, determine the volume to be excavated if the formation level is to be 1130m above mean sea level, site is divided into triangles.




Diagra

(7 marks

Reduced levels at intersections (m)

| | | |
|---|---|---|
| A = 1136.26 | E = 1134.44 | J = 1135.74 |
| B = 1133.79 | F = 1136.39 | K = 1134.85 |
| C = 1136.68 | G = 1134.88 | L = 1136.78 |
| D = 1134.25 | H = 1135.57 | M = 1135.32 |

QUESTION TWO (20 marks)

(a) Distinguish briefly between the following terms:-

(i) An open traverse and a closed traverse
(ii) Modulating waves and carrier waves in EDM instruments. (6 marks

(b) Use the following data to determine the coordinates of points NPI, NP2, NP3 and NP4, wh are new points in a traverse from TKI to TK2. The misclosure should be adjusted using th Bowditch method.

Skani: Kwa hisani ya Eric

| Station | Observation | Station | Observations |
|---|---|---|---|
| At TK1 | | At NP3 | |
| TK3 | 261° 45' 03" | NP2 | 323° 22' 10" |
| TK6 | 330° 06' 45" | NP4 | 152° 22' 06 |
| TR1 | 00° 21' 59" | | |
| NP1 | 179° 04' 38" | At NP4 | |
| | | NP3 | 332° 22' 00" |
| | | TK2 | 12° 19' 30" |
| At NP1 | | | |
| TK1 | 359°03' 44" | | |
| NP2 | 139°35' 10" | At TK2 | |
| | | NP4 | 301° 09' 20" |
| At NP3 | | TK5 | 103° 10' 24" |
| NP1 | 319° 35' 17" | TK4 | 266° 48' 02" |
| NP3 | 143° 22' 24 | | |

Datum bearing:

| | | | |
|---|---|---|---|
| TK1 – TK3: | 261° 43' 01" | TK2 – TK5: | 103° 21' 27" |
| TK1 – TK6: | 330° 04' 31" | TK2 - TK4: | 266° 58' 52" |
| TK1 – TR1: | 00° 20' 31" | | |

Traverse distances:

| | | | |
|---|---|---|---|
| TK1 – NP1: | 73.332m | NP3 – NP4: | 84.658M |
| NP1 - NP2: | 77.588m | NP4 – TK2: | 129.430m |
| NP2 – NP3 | 71.145m | | |

Datum coordinates:

| Station | N (metres) | E |
|---|---|---|
| TK1 - | 11 436.85" | -18634.07 |
| TK2 - | 11 768.10" | -18390.28 |

(14 marks)

QUESTION THREE (20 marks)

(a) Make brief comments on the following terms, as they are used in connection with mass-haul diagrams and explain their relevance in road construction projects.

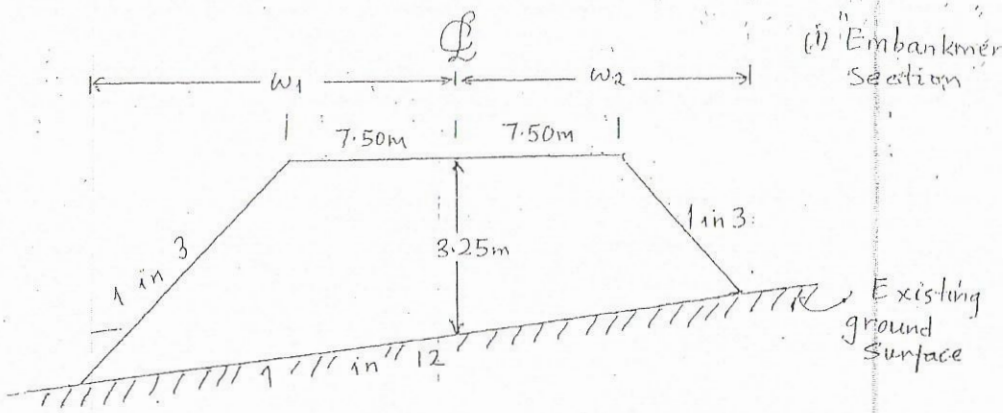
(i) Haul
(ii) Bulking and shrinkage
(iii) Borrow
(iv) Rising and falling of the curve
(v) Limit of economic haul
(vi) Balancing line. (6 marks)

(b) Explain the effect of curvature on determination of volumes of earthworks. (4 marks)

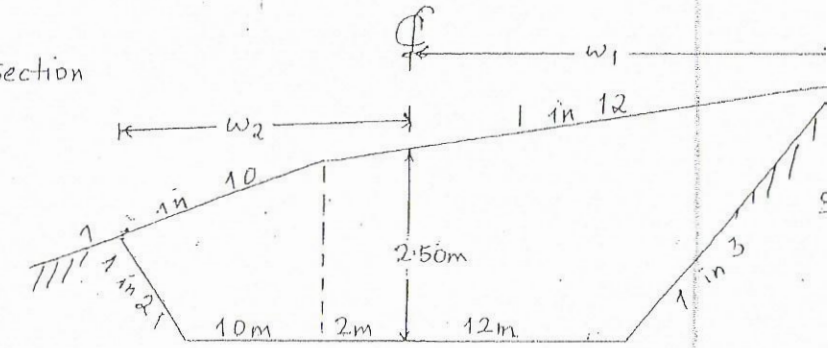
(c) Determine the side widths and areas for each of the following cross-sections:-



(i) "Embankment" Section




(ii) "Cut" section




QUESTION FOUR (20 marks)

(a) Make brief comments on the following:-

(i) Direct contouring
(ii) Invert level
(iii) Sight rails
(iv) Digital level. (6 marks)

(b) Describe a method for detection and correction of collimation error in a level. (6 marks)

(c) Observations were carried out between two stations NYATI (benchmark and M to facilitate the design of a water supply line.

From P. To benchmark NYATI and staff stations A,B,C, and D readings 2.886m, 2.685m, 2.458m, 2.234m and 2.763m respectively.

From Q: To D,E,F,G, and H readings 2.601m, - 2,156m, - 1.986m, 1.885m and 2.059m respectively.
From R: To H,J,K,L and M readings 2.134m, 1.982m, ,1.859m, 1.745m and 1.637m were obtained respectively.



Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2005/2006

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 351: ENGINEERING SURVEYING 2

DATE: 21ST FEBRUARY, 2006 TIME: 11.15 A.M. – 1.15 P.M

Answer any **three** questions.

**Question One (20 marks)**

a. Determine side widths areas for each of the following cross-sections: -

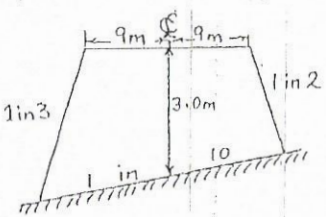
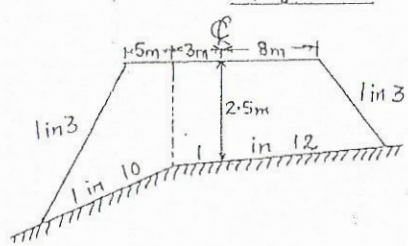



Diagram 1.

Diagram 2.



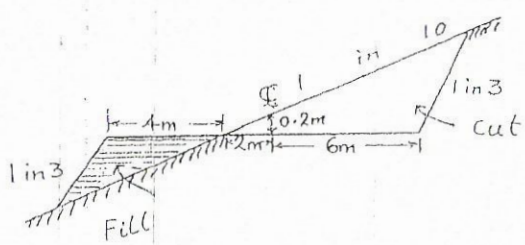




Diagram 3.

b. Explain the significance of the following in relation to Mass-Haul diagrams: -

(i) Rising and falling of the curve
(ii) Maximum and minimum points
(iii) Limit of economic haul
(iv) Balancing line
(v) Grade points

**Question Two (20 marks)**

a. Discuss how methods and instrumentation for establishment of Survey Control have changed over the last Century, giving an indication of the methods that are currently preferred.

b. Using the data given below, compute the coordinates of various control points in the following traverse. Use the Bowditch method to distribute the misclosure.

| Station | Observations | Station | Observations |
|---|---|---|---|
| At Tr 63 | | At Tr 60 | |
| Tr 65 | 83° 02′ 35″ | Tr 61 | 81° 37′ 45″ |
| Tr 75 | 263° 52′ 59″ | Tr 59 | 348° 52′ 42″ |
| Tr 62 | 170° 11′ 37″ | | |
| At Tr 62 | | At Tr 59 | |
| Tr 63 | 350° 11′ 37″ | Tr 60 | 168° 52′ 34″ |
| Tr 61 | 261° 34′ 04″ | Tr 75 | 89° 09′ 50″ |
| | | Tr 58 | 351° 53′ 46″ |
| At Tr 61 | | | |
| Tr 62 | 81° 34′ 04″ | | |
| Tr 60 | 261° 37′ 39″ | | |

Traverse distances:
Tr 63 – Tr 62: 184.618m
Tr 62 – Tr 61: 157.456m
Tr 61 – Tr 60: 154.764m
Tr 60 – Tr 59: 212.277m

Datum coordinates:

| Station | N (metres) | E |
|---|---|---|
| Tr 63 | - 6 770.23 | - 17 705.56 |
| Tr 59 | - 6 789.28 | - 18 023.95 |

Skani: Kwa hisani ya Eric

Given that the reduced level of NYATI is 880.50m

(i) Determine the reduced levels at all staff stations.

(ii) If a boning rod of length 3.50m is to be used during excavation and setting out, determine the height of sight rails above the ground at C,G and L given that the distance between C and G is 120.00m and that between G and L is 112.5m. The design gradients are 1:200, rising from C to G and 1:150 rising from G to L. The invert level at C is 878.50m above mean sea level. (8 marks)



Skani: Kwa hisani ya Eric

Datum bearings

Tr 63 – Tr 65: 83° 04′ 42″
Tr 63 – Tr 75: 263° 55′ 00″
Tr 59 – Tr 75: 89° 11′ 42″
Tr 59 – Tr 58: 351° 55′ 48″

**Question Three (20 marks)**

a. Describe a method for detection and correction of collimation error in a level.

b. Observations were carried out between two stations BM11 (benchmark) and Q to facilitate the design of a water supply line.

From X: To benchmark BM11 and staff stations A1, A2, A3 and B readings 3.012m, 3.002m, 2.776m, 2.113m and 2.527m respectively.

From Y: To B, B1, B2, B3 and B4 readings 2.601m, -2.156m, -1.996m, 1.885m and 2.059m respectively.

From Z: To B4, C1, C2, C3 and Q readings 2.111m, 1.992m, 1.813m, 1.715m and 1.667m were obtained respectively.

(i) Given that the reduced level of BM11 is 952.510m, determine the reduced level at all staff stations.

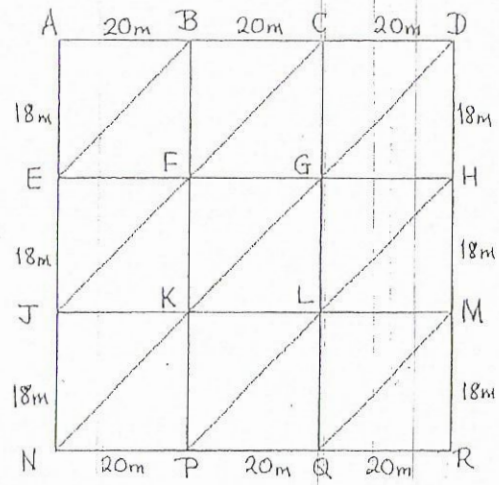
(ii) If a boning rod of length 3.50m is used during excavation and setting out, determine the height of sight-rails above the ground at A3, B3 and C3 given that distance between A3 and B3 is 80.00m and 60.00m between B3 and C3. The design gradients are 1:100, rising from A3 to B3, and 1:80 rising from B3 to C3. The reduced level of the invert at A3 is 950.50m.

**Question Four (20 marks)**

a. State the main sources of error in ordinary leveling, stating precautions that should be taken to minimize the errors.

b. Spot heights were taken at grid intersections at a small site and subsequently used to estimate the volume of material t be excavated in the construction of a high-rise building. If t formation level of the building is to be 850.00m above mean sea level, calculate the volume of material to be excavated, i the site is divided up into triangles, as shown on *Diagram 4*

*Diagra*




*Reduced levels at grid corners (m)*

| | | | |
|---|---|---|---|
| A = 852.39 | B = 852.87 | C = 853.42 | D = 853.96 |
| E = 852.27 | F = 853.18 | G = 853.92 | H = 854.45 |
| J = 852.15 | K = 853.47 | L = 853.79 | M = 854.50 |
| N = 851.21 | P = 850.75 | Q = 852.25 | R = 854.11 |

c. Use both the Mean Areas and Prismoidal Formulae to determine the increase in the volume of water, above the 900.00m contour, in a Reservoir after extension of an existi dam. Areas that are expected to be under water are as indicated on *Table1*.

*Tab*

| Contour (m) | 900 | 920 | 940 | 960 | 980 | 1000 | 102 |
|---|---|---|---|---|---|---|---|
| Area enclosed by contour (m²) | 12175 | 13811 | 15799 | 19675 | 22178 | 25776 | 310 |

Skani: Kwa hisani ya Eric

Question Five (20 marks)

a. Write short notes on the following: -

(i) Modulating waves in Electromagnetic Distance Measuring Equipment
(ii) Classification of EDM equipment by carrier waves
(iii) Sources of error in Electromagnetic Distance Measurement
(iv) The difference between Inertial Surveying and Satellite Position Fixing.

b. The following readings were taken onto a vertical staff held at stations H and J, from an instrument station X. The height of instrument was 1.54m and the reduced level of the instrument station was 1100.00m. If the multiplying constant of the instrument (theodolite) was 100, determine: -

(i) The reduced levels at H and J
(ii) The gradient between H and J

*Table 2*

| Staff Station | Horizontal Reading | Stadia Readings (m) | Vertical Angle |
|---|---|---|---|
| H | 45° 30′ | 1.017, 1.898, 2.779 | - 5° 15′ |
| J | 105° 30′ | 1.296, 2.215, 3.134 | + 8° 39′ |

Skani: Kwa hisani ya Eric

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 311 : GEOTECHNICAL ENGINEERING I

DATE: JANUARY 30, 2012 TIME: 11.15AM – 1.15PM

INSTRUCTIONS:

Answer any Three Questions

## QUESTION ONE

I) Define the term weathering. (2 marks)

II) Explain the two important classifications of weathering processes. (6 marks)

III) Write short notes on Montmorillonite, Kaolite and Illite clay minerals. (6 marks)

IV) Describe the two basic structural units of clay minerals. (6 marks)

## QUESTION TWO

I) Distinguish between.
   a) Void ratio and porosity
   b) Water content and air content
   c) Specific volume and specific gravity. (3 marks)

II) The moisture content of a saturated soil $W_{sat}$ is 35% and the relative density "$G_s$" of its particles is 2.7. Find the void ratio "e" and the porosity "n". What will be the degree of saturation $S_r$ and the air content "A" if the moisture content "w" gets reduced to 5% on drying? (7 marks)

III) The mass M of an undisturbed sample is 1250g and its volume is 630 $cm^3$. On oven drying, the sample weighs 1102 g. The average relative density $G_s$ of soil is 2.68. Find the bulk density, natural moisture content w, dry density $\rho_d$, void ration e, degree of saturation $S_r$, and the air content A. What will be the density and unit weight on full saturation? (10 marks)

## QUESTION THREE

I) Explain salient features of a plasticity chart as used in the British Soil Classification. (5 marks)

II) Explain the determination of field density using the sand replacement method fo cohesionless soils. (5 marks

III) Given the particle-distribution curve in Fig. Q3, determine the gradation of Soil Soil B, and Soil C. (6 marks

IV) Determine the coefficient of uniformity and coefficient of curvature of Soil C. (4 marks

## QUESTION FOUR

I) Define the term compaction. (2 marks

II) By use of a Typical Compaction Curve, explain the theory of compaction . (8 marks

III) Explain the effect of varying the following factors in the compaction curve;
   a) Variation in compaction effort
   b) Variation in soil grading soil type (10 marks)

Skani: Kwa hisani ya Eric

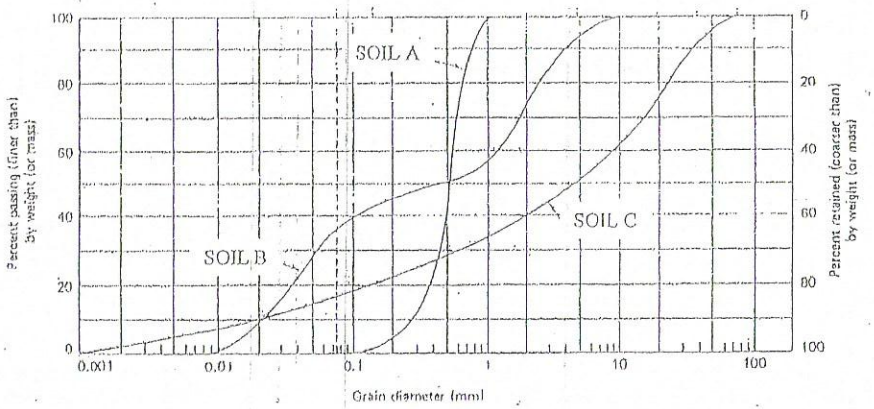



*Fig. Q3 : Particle –Size Distribution Curves*

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2010/2011

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 311: GEOTECHNICAL ENGINEERING

DATE: FEBRUARY 14, 2011 TIME: 11.15AM - 1.15PM

*Instructions: Answer any Three Questions*

1. (I) Define the term Weathering (2 Marks)

(II) Explain the two important classifications of weathering processes (8 Marks)

(III) By using well labelled diagrams, describe any two Atomic and Molecular bonds and how they build up the structure of substances (10 Marks)

Skani: Kwa hisani ya Eric

2. (I) Distinguish between

(a) Void ratio and porosity
(b) Water content and air content
(c) Specific volume and specific gravity

(3 Marks)

(II) With the usual notations, show that;

$$\rho_d = \frac{\rho}{1+w}$$

(7 Marks)

(III) The mass M of an undisturbed sample is 1250 g and its volume V is 630 $cm^3$. On oven drying, the sample weighs 1102 g ($M_s$). The average relative density $G_s$ of soil is 2.68. Find;

**Hint:** $\rho = \frac{G_s \rho_w (1+w)}{1+e}$. Water density, $\rho_w$, is known to be 1,000 $kg/m^3$.

(a) Bulk density, $\rho$;
(b) Natural moisture content, $w$;
(c) Dry density, $\rho_d$;
(d) Void ratio, $e$;
(e) Degree of saturation, $S_r$;

(10 Marks)



3. (I) Describe the four states of consistency as suggested by Atterberg using neat diagram.

(4 Ma

(II) Describe the laboratory method of determination of Liquid Limit using Casagrande Apparatus.

(10 M

(III) The properties of a subgrade soil are found as follows;
a) Per cent finer than 0.075mm = 55%
b) Liquid limit = 40%
c) Plastic limit = 30%

Classify the soil according to the Unified Soil Classification System. Th USC Plasticity Chart is shown in Fig. Q3 below.

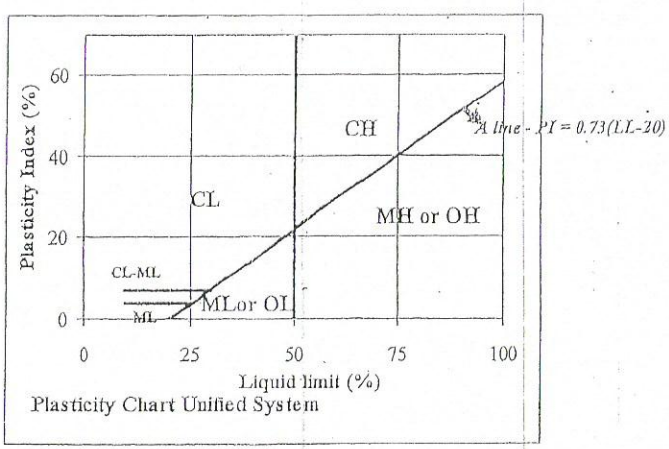



Fig. Q3; Plasticity Chart for Unified Soil Classification System

(6 Mar



Skani: Kwa hisani ya Eric

4. (I) Define the term Compaction (2 Marks)

(II) By use of a Typical Compaction Curve, explain the Theory of Compaction (8 Marks)

(III) Explain using the Compaction Curve the effect of varying the Compaction Effort (10 Marks)



# UNIVERSITY OF NAIROBI

SECOND SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

FCE 311: GEOTECHNICAL ENGINEERING

DATE: JULY 16, 2010 TIME: 11.15 – 1.15PM

Instructions:

1. Answer Any Three questions.
2. All questions carry equal marks.

1. a) Briefly explain the meaning of the terms "Dispersed layers" and "Cation exchange" of clay mineral particles. [6 marks

b) Results of a particle size analysis of two soils A and B are as below:

| Size (Sieve)mm | 20.0 | 10.0 | 5.0 | 2.36 | 1.18 | 0.6 | 0.3 | 0.21 | 0.15 | 0.075 | 0.02 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mass Retained Soil A (g) | 16 | 21 | 21 | 28 | 24 | 21 | 41 | 32 | 16 | 15 | 8 | 7 |
| Mass Retained Soil B (g) | 3 | 2 | 5 | 8 | 7 | 11 | 21 | 63 | 48 | 14 | 2 | 2 |

i) Calculate the cumulative mass retained in each sieve and hence the percenta passing each size and plot the particle size distribution curves for the two so in the semi-log chart provided. (fig. Q1b).

ii) Calculate the effective size and co-efficient of uniformity for the two soils.

iii) Comment on the classification of the two soils.

[14 mark

2. a) Define the term soil "phase" and state its importance in engineering.



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2. (I) Distinguish between

(a) Void ratio and porosity
(b) Water content and air content
(c) Specific volume and specific gravity

(3 Marks)

(II) With the usual notations, show that;

$$\rho_d = \frac{\rho}{1+w}$$

(7 Marks)

(III) The mass M of an undisturbed sample is 1250 g and its volume V is 630 $cm^3$. On oven drying, the sample weighs 1102 g ($M_s$). The average relative density $G_s$ of soil is 2.68. Find;

**Hint:** $\rho = \frac{G_s \rho_w (1+w)}{1+e}$. Water density, $\rho_w$, is known to be 1,000 $kg/m^3$.

(a) Bulk density, $\rho$;
(b) Natural moisture content, $w$;
(c) Dry density, $\rho_d$;
(d) Void ratio, $e$;
(e) Degree of saturation, $S_r$;

(10 Marks)



3. (I) Describe the four states of consistency as suggested by Atterberg using neat diagram.

(4 Ma

(II) Describe the laboratory method of determination of Liquid Limit using Casagrande Apparatus.

(10 M

(III) The properties of a subgrade soil are found as follows;
a) Per cent finer than 0.075mm = 55%
b) Liquid limit = 40%
c) Plastic limit = 30%

Classify the soil according to the Unified Soil Classification System. Th USC Plasticity Chart is shown in Fig. Q3 below.

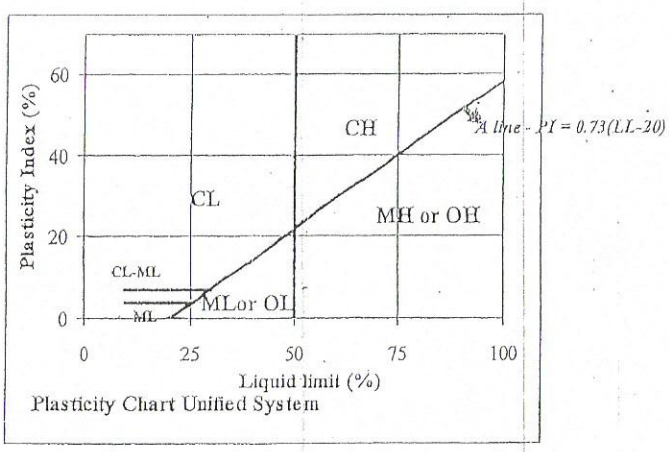


Fig. Q3; Plasticity Chart for Unified Soil Classification System

(6 Mar



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4. (I) Define the term Compaction (2 Marks)

(II) By use of a Typical Compaction Curve, explain the Theory of Compaction (8 Marks)

(III) Explain using the Compaction Curve the effect of varying the Compaction Effort (10 Marks)



# UNIVERSITY OF NAIROBI

SECOND SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVI
ENGINEERING

FCE 311: GEOTECHNICAL ENGINEERING

DATE: JULY 16, 2010 TIME: 11.15 – 1.15P

Instructions:

1. Answer Any Three questions.
2. All questions carry equal marks.

1. a) Briefly explain the meaning of the terms "Dispersed layers" and "Cation exchange" of clay mineral particles. [6 mar

b) Results of a particle size analysis of two soils A and B are as below:

| Size (Sieve)mm | 20.0 | 10.0 | 5.0 | 2.36 | 1.18 | 0.6 | 0.3 | 0.21 | 0.15 | 0.075 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mass Retained Soil A (g) | 16 | 21 | 21 | 28 | 24 | 21 | 41 | 32 | 16 | 15 | 8 |
| Mass Retained Soil B (g) | 3 | 2 | 5 | 8 | 7 | 11 | 21 | 63 | 48 | 14 | 2 |

i) Calculate the cumulative mass retained in each sieve and hence the percen passing each size and plot the particle size distribution curves for the two in the semi-log chart provided. (fig. Q1b).

ii) Calculate the effective size and co-efficient of uniformity for the two soils.

iii) Comment on the classification of the two soils.

[14 mar

2. a) Define the term soil "phase" and state its importance in engineering.



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b) Define the following phase properties of soils:

- Porosity
- Specific volume
- Specific gravity
- Dry density
- Bulk density

c) A soil specimen is 38mm in diameter and 76mm long and weighs 168g in its natural state. When dried completely in an oven, the weight reduced to 130.5g. the value of the soils specific gravity of solid particles is 2.73. Determine the following:

i) Total volume and water content of the soil specimen.

ii) Volume of water, air and solid phases in the specimen.

iii) Void ratio, air content and degree of saturation of the soil.

3. a) Reduction of volume of voids is the major soil improvement technique in earthworks and is achieved through the processes of "compaction" and "consolidation". Outline the two processes and highlight their effects on engineering properties of earthworks.

b) A standard compaction test carried out on a sample of soil on an earthworks project yielded the following results.

| | | | | | |
|---|---|---|---|---|---|
| Bulk Density Kg/m³ | 2058 | 2125 | 2152 | 2159 | 2140 |
| Water Content % | 12.9 | 14.3 | 15.7 | 16.9 | 17.9 |

If the specific gravity of the solids is 2.73, calculate the corresponding values of dry densities and plot the dry density – water content proctor curve. Determine the MDD and OMC.

c) Calculate the value of void ratio, air content and degree of saturation at MDD and OMC.

a) Briefly describe the state of the porewater pressure at the following locations:

i) At ground water table

ii) Above the ground water table

iii) Below the ground water table [5 marks]

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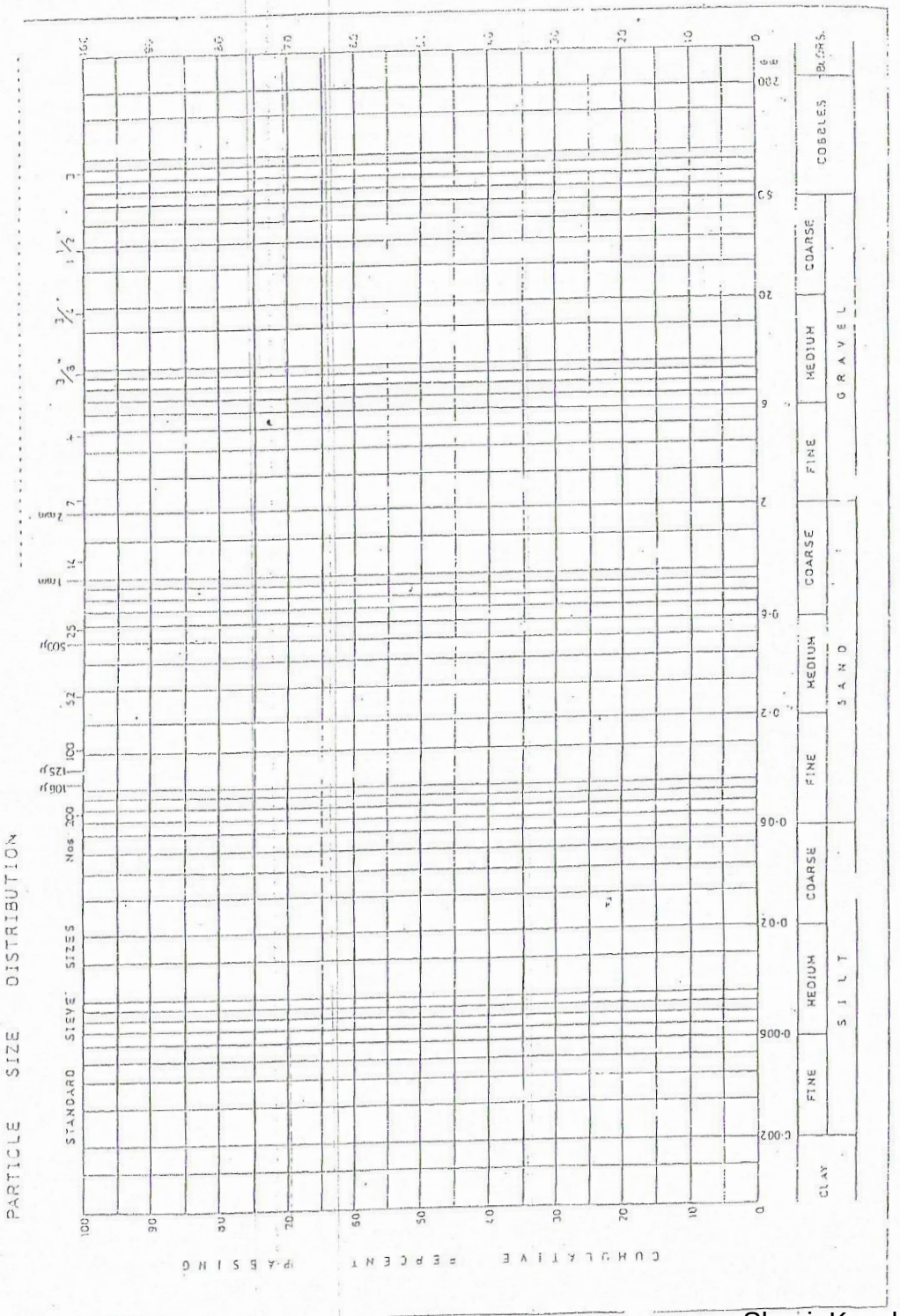
b) Figure Q 4b shows a layer of sandy silt 3.0 metres thick overlying a 3.5 m thick layer of clayey silt. Below the two layers is an impermeable rock str water table fluctuates with rain seasons. Assume the information given i figure and calculate the total, effective and pore water pressures at positi and 3.

i) When the water table is at ground level

ii) When the water table is at position 2

iii) When the water table is at 4.5m below ground level. [10

c) Discuss the difficulties of estimating the site value of the coefficient of per from laboratory tests. [5 r

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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREES OF BACHELOR OF SCIENCE IN ENGINEERING

FEB 313 : ENVIRONMENTAL AND BIOSYSTEM ENGINEERING
FCE 361 : CIVIL ENGINEERING
FEE 371 : ELECTRICAL AND ELECTRONIC ENGINEERING
FME 371: MECHANICAL ENGINEERING
FGE 381 : GEOSPATIAL ENGINEERING

ENGINEERING MATHEMATICS III

DATE: JANUARY 23, 2012 TIME: 11.15 A.M. – 1.15 P.M.

INSTRUCTIONS

Answer Question ONE and TWO other Questions.

Question 1 : (32 marks)

(a) Prove that:

i) $\nabla.(\bar{A}+\bar{B}) = \nabla.\bar{A}+\nabla.\bar{B}$

ii) $\nabla.(\phi\bar{A}) = \nabla\phi.\bar{A}+\phi\nabla.\bar{A}$

where $\bar{A}$ and $\bar{B}$ are vectors and $\phi$ is scalar. (7 marks)

(b) Find the total work done in moving a particle in a force field given by

$\bar{F} = 3xy\hat{i} - 5z\hat{j} + 10x\hat{k}$ along the curve $x = t^2+1, y = 2t^2, z = t^3$ (6 marks)

# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2010/2011

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

FEB 313: ENVIRONMENTAL AND BIOSYSTEM ENGINEERING
FCE 361: CIVIL ENGINEERING
FEE 371: ELECTRICAL AND ELECTRONIC ENGINEERING
FME 371: MECHANICAL ENGINEERING
FGE 381: GEOSPATIAL ENGINEERING

ENGINEERING MATHEMATICS III

DATE: 7 FEBRUARY 2011 TIME: 11.15 A.M - 1.15 P.M.

INSTRUCTIONS
Answer Question ONE and TWO other Questions.

QUESTION ONE (32 MARKS)

(a) Prove that

(i) $\nabla(F+G) = \nabla F + \nabla G$

(ii) $\nabla(FG) = F\nabla G + G\nabla F$

Where F and G are scolars. (7 Marks)

(b) If $u = \frac{y}{z} + \frac{z}{x} + \frac{x}{y}$, show that $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} + z\frac{\partial u}{\partial z} = 0$ (6 Marks)

(c) Express $\nabla\phi$ in orthogonal curvilinear coordinate system. (7 Marks)



$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ 0 & -\frac{\sqrt{3}}{2} & -\frac{1}{2} \end{bmatrix}$$ orthogonal?

(6 Marks)

(e) If

$z_1 = f_1(x_1)$
$z_2 = f_2(x_1, x_2)$
$z_3 = f_3(x_1, x_2, x_3)$
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---
---
$z_n = f_n(x_1, x_2, \ldots\ldots x_n)$

then prove that

$$\frac{\partial(z_1, z_2, \ldots\ldots, z_n)}{\partial(x_1, x_2, \ldots\ldots x_n)} = \frac{\partial z_1}{\partial x_1} \cdot \frac{\partial z_2}{\partial x_2} \cdots\cdots \frac{\partial z_n}{\partial x_n}$$

(6 Marks)

QUESTION TWO (24 MARKS)

(a) Verify Green's theorem in the plane for

$$\oint_c (xy + y^2)\,dx + x^2\,dy$$

where c is a closed curve of the region bounded by $y = x$ and $y = x^2$

(8 Marks)

(b) If $\vec{r} + x\hat{i} + y\hat{j} + z\hat{k}$ then prove

(i) $\nabla^2\left(\frac{1}{r}\right) = 0$ (ii) $\nabla \cdot \left(\frac{\vec{r}}{r^3}\right) = 0$



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**Question 3 : (24 marks)**

(a) Verify the divergence theorem for

$$\bar{F} = (x^2 - yz)\bar{i} + (y^2 - zx)\bar{j} + (z^2 - xy)\bar{k}$$

taken over the rectangular parallelepiped

$o \le x \le a, o \le y \le b, o \le z \le c$ (8 marks)

(b) Verify Green's theorem in the plane for

$$\oint_c (xy + y^2)dx + x^2 dy$$

Where C is a closed curve of the region bounded by $y = x$ and $y = x^2$

(8 marks)

(c) Prove

$$\iiint_V (\phi\nabla^2\varphi - \varphi\nabla^2\phi)dv$$
$$= \iint_s (\phi\nabla\varphi - \varphi\nabla\phi).d\bar{s}$$

(8 marks)

**Question 4 : (32 marks)**

(a) If $u = f(x, y)$ where $x = \phi(t)$ and $y = \varphi(t)$ then prove (8 marks)

$$\frac{du}{dt} = \frac{\partial u}{\partial x}.\frac{dx}{dt} + \frac{\partial u}{\partial y}.\frac{dy}{dt}$$

(b) If k is the area of a triangle with sides a,b,c show that

$$\left(\frac{\partial k}{\partial a}\right)_{b,c} = \frac{a}{2}\cot A$$ (8 marks)

(c) If $x = r\cos\theta, y = r\sin\theta$, prove that



$$\frac{\partial^2 r}{\partial x^2} + \frac{\partial^2 r}{\partial y^2} = \frac{1}{r}\left\{\left(\frac{\partial r}{\partial x}\right)^2 + \left(\frac{\partial r}{\partial y}\right)^2\right\}$$ ( 8 marks)

**Question 5 : (24 marks)**

(a) Prove Taylor's theorem

$$f(x+h, y+k) = f(x,y) + h\frac{\partial f}{\partial x} + k\frac{\partial f}{\partial y} + \frac{1}{2!}\left[h^2\frac{\partial^2 f}{\partial x^2} + 2hk\frac{\partial^2 f}{\partial x \partial y} + k^2\frac{\partial^2 f}{\partial y^2}\right] + \ldots$$

(7 marks)

(b) Given matrix

$$\begin{bmatrix} 3 & 1 & 2 \\ 2 & -3 & -1 \\ 1 & 2 & 1 \end{bmatrix}$$

Find Adj(A) and hence solve system of equations

$$\begin{aligned} 3x + y + 2z &= 3 \\ 2x - 3y - z &= -3 \\ x + 2y + z &= 4 \end{aligned}$$

(10 marks)

(c) A rectangular box open at the top is to have volume of 32 $m^3$. Find the dimensions of the box requiring least material for its construction.

(7 marks)

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# UNIVERSITY OF NAIROBI

SUPPLEMENTARY SPECIAL EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

| | |
|---|---|
| FEB 313: | ENVIRONMENTAL AND BIOSYSTEMS ENGINEERING |
| FCE 361: | CIVIL ENGINEERING |
| FEE 371: | ELECTRICAL AND ELECTRONIC ENGINEERING |
| FGE 381: | GEOSPATIAL ENGINEERING |

DATE: OCTOBER 19, 2010 TIME: 11.15AM- 1.15PM

Instructions: Answer QUESTION ONE and any TWO OTHER questions.

## Question 1 [32 Marks]

a) Prove that:

i) $\nabla(F+G)=\nabla D+\nabla G$

ii) $\nabla(FG)=F\nabla G+G\nabla F$

Where F and G are scalars. [7 marks]

b) If $a$ and $b$ are two sides of a right angled triangle with hypotenuse $c$ and $p$ being the perpendicular from the opposite vertex on the hypotenuse, show that:

i) $\left(\frac{\partial p}{\partial a}\right)_b=\frac{b^3}{c^3}$

ii) $\left(\frac{\partial p}{\partial a}\right)_A=\frac{b}{c}$ [7 marks]

c) Give a definition of $\iint_s \bar{A}.\hat{n}ds$ over a surface s in terms of limit of a sum. [6 marks]

d) If
$$z_1=f_1(x_1)$$
$$z_2=f_2(x_1,x_2)$$
$$z_3=f_3(x_1,x_2,x_3)$$
$$----------$$
$$----------$$
$$z_n=f_n(x_1,x_2,----------x_n)$$

then prove that

$$\frac{\partial(z_1,z_2,----,z_n)}{\partial(x_1,x_2,----,x_n)}=\frac{\partial z_1}{\partial x_1}.\frac{\partial z_2}{\partial x_2}.----\frac{\partial z_n}{\partial x_n}$$ [6 marks]

e) Is matrix

$$\begin{bmatrix}1 & 0 & 0\\ 0 & -\frac{1}{2} & \frac{\sqrt{3}}{2}\\ 0 & -\frac{\sqrt{3}}{2} & -\frac{1}{2}\end{bmatrix}$$ orthogonal? [6 marks]

## Question 2 [24 Marks]

a) Verify Green's theorem in 7th plane for

$$\oint_C (xy+y^2)dx+x^2dy$$

Where $C$ is the closed curve of the region bounded by $y=x$ and $y=x^2$. [8 marks]

b) Find a unit normal vector to the level surface $x^2y+2xz=4$ at the point (2, -2, 3). [8 marks]

c) Evaluate $\iint_s F.\hat{n}ds$, where $\bar{F}=4xz\tilde{i}-y^2\hat{j}+yz\tilde{k}$

and $S$ is the surface of the cube bounded by $x=0,\ x=1,\ y=1,\ z=0,\ z=1$. [8 marks]

## Question 3 [24 Marks]

a) If $\bar{A}=(3x^2+6y)\tilde{i}-14yz\tilde{j}+20xz^2\tilde{k}$



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(c) Find a unit normal vector to the level surface

$$x^2y+2xz=4$$

at the point $(2,-2,3)$ (8 Marks)

## QUESTION THREE (24 MARKS)

(a) Show that in orthogonal curvilinear coordinate system

$$\nabla x\bar{A} = \frac{1}{h_1 h_2 h_3}\begin{vmatrix} h_1e_1 & h_2e_2 & h_3e_3 \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ A_1h_1 & A_2h_2 & A_3h_3 \end{vmatrix}$$

(8 Marks)

(b) Verify the divergence theorem for

$$\vec{F} = 4xz\hat{i} - y^2\hat{j} + yz\hat{k}$$

taken over the cube $0 \le x \le 1,\ 0 \le y \le 1\ \ 0 \le z \le 1$

(10 Marks)

(c) Express Stoke's theorem in words and write it in rectangular form.

(6 Marks)

## QUESTION FOUR (24 MARKS)

(a) If $u = f(x_1, x_2, \ldots\ldots\ldots x_n)$ where $x_1 = \phi_1(t),\ x_2 = \phi_2(t), \ldots\ldots, x_n = \phi_n(t)$ then prove

$$\frac{du}{dt} = \frac{\partial u}{\partial x_1}\cdot\frac{dx_1}{dt} + \frac{\partial u}{\partial x_2}\cdot\frac{dx_2}{dt} + \cdots + \frac{\partial u}{\partial x_n}\cdot\frac{dx_n}{dt}$$

(8 Marks)

(b) If $x = r\cos\theta,\ y = r\sin\theta$ then show that

$$\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2} = 0$$

(8 Marks)

(c) If K is the area of a triangle with sides a, b, c, show that

$$\left(\frac{\partial K}{\partial a}\right)_{b,c} = \frac{a}{2}\ Cot\ A$$

(8 Marks)



## QUESTION FIVE (24 MARKS)

(a) Find a point within a triangle such that the sum of the squares of its distances from the three verticies is minimum. (8 Marks)

(b) Prove that any square matrix can be expressed uniquely as the sum of a symmetric and a skew symmetric matrix. (6 Marks)

(c) Given matrix

$$A = \begin{bmatrix} 5 & 3 & 7 \\ 1 & 5 & 2 \\ 7 & 2 & 10 \end{bmatrix}$$

Find Adj (A) and hence solve the system of equations:

$$5x + 3y + 7z = 4$$
$$x + 5y + 2z = 2$$
$$7x + 2y + 10z = 5$$

By using matrix method. (10 Marks)

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evaluate $\int \vec{A}.d\vec{r}$ from (0, 0, 0) to (1, 1, 1) along the path $C^c$ given as $x=t,\ y=t^2,\ z=t^3$. [6 marks]

b) Write
i) Stroke's theorem in rectangular form
ii) Divergence theorem in rectangular form [8 marks]
iii)

c) Show that in orthogonal curvilinear coordinate system

i) $\nabla.(A,\hat{e}_1)=\frac{1}{h_1h_2h_3}\frac{\partial}{\partial u_1}(A_1h_2h_3)$

ii) $\nabla X(A,\hat{e}_1)=\frac{\hat{e}_2}{h_3h_1}\frac{\partial}{\partial u_3}(A_1h_1)-\frac{\hat{e}_3}{h_1h_2}\frac{\partial}{\partial u_2}(A_1h_1)$ [10 marks]

**Question 4 [24 Marks]**

a) If $x=r\cos\theta,\ \ y=r\sin\theta$ then show that

$$\frac{\partial^2\theta}{\partial x^2}+\frac{\partial^2\theta}{\partial y^2}=0$$ [8 marks]

b) Find a point within a triangle such that the sum of the squares of its distances form three vertices is minimum. [8 marks]

c) If $U=f(x,y)$, where $x=\phi(t)$ and $y=\psi(t)$, then prove that

$$\frac{du}{dt}=\frac{\partial u}{\partial x}.\frac{\partial x}{\partial t}+\frac{\partial u}{\partial y}.\frac{\partial y}{\partial t}$$ [8 marks]

**Question 5 [24Marks]**

a) Prove that any square matrix can uniquely be expressed as the sum of a symmetric and skew symmetric matrix. [7 marks]

b) If $K$ is the area of a triangle with sides $a, b, c$, show that

$$\left(\frac{\partial k}{\partial a}\right)_{b,c}=\frac{a}{z}\cot A$$ [7 marks]

c) Given matrix

$$\begin{bmatrix} 2 & -2 & 4 \\ 2 & 3 & 2 \\ -1 & 1 & -1 \end{bmatrix}$$

find Ady (A) and hence solve the system of equations

$2x-2y+4z=-12$
$2x+3y+2z=8$
$-x+y-z=\frac{1}{2}$

by using the matrix method. [10 marks]



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# UNIVERSITY OF NAIROBI

FIRST SEMESTER EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREES OF BACHELOR OF SCIENCE IN ENGINEERING:

FEB 313: ENVIRONMENTAL AND BIOSYSTEMS ENGINEERING
FCE 361: CIVIL ENGINEEERING
FEE 371: ELECTRICAL AND ELECTRONIC ENGINEERING
FME 371: MECHANICAL ENGINEERING
FGE 371: GEOSPATIAL ENGINEERING

ENGINEERING MATHEMATICS III

DATE: 8TH FEBRUARY 2010 TIME: 11.15 – 1.15 P.M.

INSTRUCTIONS
Answer question ONE and TWO other questions.

QUESTION 1 (32 MARKS)

(a) Prove that

(i) $\nabla\cdot(\vec{A}+\vec{B}) = \nabla.\vec{A}+\nabla.\vec{B}$

(ii) $\nabla\cdot(\phi\vec{A}) = \nabla\phi.\vec{A}+\phi\nabla.\vec{A}$

Where $\vec{A}$ and $\vec{B}$ are vectors and $\phi$ is scalar (7 Marks)

(b) If $u = F(x-y,\ y-z,\ z-x)$ prove that

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}+\frac{\partial u}{\partial z} = 0$$ (6 Marks)

(c) Express Green's theorem in the plane in vector notation. (7 Marks)



(d) If $u, v$ are functions of $r, s$ and $r, s$ are functions of $x, y$ then prove that:

$$\frac{\partial(u,v)}{\partial(x,y)} = \frac{\partial(u,v)}{\partial(r,s)}\cdot\frac{\partial(r,s)}{\partial(x,y)}$$

(e) Is matrix

$$\begin{pmatrix} \frac{1}{3} & \frac{2}{3} & \frac{2}{3} \\ \frac{2}{3} & \frac{1}{3} & -\frac{2}{3} \\ \frac{2}{3} & -\frac{2}{3} & \frac{1}{3} \end{pmatrix}$$

orthogonal? (6 Marks)

QUESTION 2 (24 MARKS)

(a) Find the work done in moving a particle in a force field given by:

$$\vec{F} = 3xy\hat{i} - 5z\hat{j} + 10x\hat{k}$$

along the curve $x = t^2+1,\ y = 2t^2,\ z = t^3$ from $t = 1$ to $t = 2$. (8 Marks)

(b) Prove Green's theorem in the plane if C is a closed curve which has the property that any straight line parallel to the coordinate axes cuts C in atmost two points. (8 Marks)

(c) If $\vec{r} = x\hat{i}+y\hat{j}+z\hat{k}$ then prove that:

(i) $\nabla^2\left(\frac{1}{r}\right) = 0$

(ii) $\Delta\cdot\left(\frac{\vec{r}}{r^3}\right) = 0$ (8 Marks)

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# UNIVERSITY OF NAIROBI

SUPPLEMENTARY SPECIAL EXAMINATIONS 2009/2010

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

| | |
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| FEB 313: | ENVIRONMENTAL AND BIOSYSTEMS ENGINEERING |
| FCE 361: | CIVIL ENGINEERING |
| FEE 371: | ELECTRICAL AND ELECTRONIC ENGINEERING |
| FGE 381: | GEOSPATIAL ENGINEERING |

DATE: OCTOBER 19, 2010 TIME: 11.15AM- 1.15PM

Instructions: Answer QUESTION ONE and any TWO OTHER questions.

## Question 1 [32 Marks]

a) Prove that:

i) $\nabla(F+G)=\nabla D+\nabla G$

ii) $\nabla(FG)=F\nabla G+G\nabla F$

Where F and G are scalars. [7 marks]

b) If $a$ and $b$ are two sides of a right angled triangle with hypotenuse $c$ and $p$ being the perpendicular from the opposite vertex on the hypotenuse, show that:

i) $\left(\frac{\partial p}{\partial a}\right)_b=\frac{b^3}{c^3}$

ii) $\left(\frac{\partial p}{\partial a}\right)_A=\frac{b}{c}$ [7 marks]

c) Give a definition of $\iint_s \vec{A}.\hat{n}ds$ over a surface s in terms of limit of a sum. [6 marks]

d) If

$$z_1=f_1(x_1)$$
$$z_2=f_2(x_1,x_2)$$
$$z_3=f_3(x_1,x_2,x_3)$$
$$----------$$
$$----------$$
$$z_n=f_n(x_1,x_2,----------x_n)$$

then prove that

$$\frac{\partial(z_1,z_2,----,z_n)}{\partial(x_1,x_2,----,x_n)}=\frac{\partial z_1}{\partial x_1}.\frac{\partial z_2}{\partial x_2}.----\frac{\partial z_n}{\partial x_n}$$ [6 marks]

e) Is matrix

$$\begin{bmatrix}1 & 0 & 0\\ 0 & -\frac{1}{2} & \frac{\sqrt{3}}{2}\\ 0 & -\frac{\sqrt{3}}{2} & -\frac{1}{2}\end{bmatrix}$$ orthogonal? [6 marks]

## Question 2 [24 Marks]

a) Verify Green's theorem in 7th plane for

$$\oint_C (xy+y^2)dx+x^2dy$$

Where $C$ is the closed curve of the region bounded by $y=x$ and $y=x^2$. [8 marks]

b) Find a unit normal vector to the level surface $x^2y+2xz=4$ at the point (2, -2, 3). [8 marks]

c) Evaluate $\iint_s F.\hat{n}ds$, where $\vec{F}=4xz\vec{i}-y^2\hat{j}+yz\vec{k}$ and $S$ is the surface of the cube bounded by $x=0$, $x=1$, $y=1$, $z=0$, $z=1$. [8 marks]

## Question 3 [24 Marks]

a) If $\vec{A}=(3x^2+6y)\vec{i}-14yz\vec{j}+20xz^2\vec{k}$



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(e) Find a unit normal vector to the level surface

$$x^2y+2xz=4$$

at the point $(2,-2,3)$ (8 Marks)

## QUESTION THREE (24 MARKS)

(a) Show that in orthogonal curvilinear coordinate system

$$\nabla x\bar{A} = \frac{1}{h_1 h_2 h_3}\begin{vmatrix} h_1e_1 & h_2e_2 & h_3e_3 \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ A_1h_1 & A_2h_2 & A_3h_3 \end{vmatrix}$$

(8 Marks)

(b) Verify the divergence theorem for

$$\bar{F} = 4xz\hat{i} - y^2\hat{j} + yz\hat{k}$$

taken over the cube $0 \le x \le 1,\ 0 \le y \le 1\ \ 0 \le z \le 1$

(10 Marks)

(c) Express Stoke's theorem in words and write it in rectangular form.

(6 Marks)

## QUESTION FOUR (24 MARKS)

(a) If $u = f(x_1, x_2, \ldots\ldots\ldots x_n)$ where $x_1 = \phi_1(t),\ x_2 = \phi_2(t), \ldots\ldots, x_n = \phi_n(t)$ then prove

$$\frac{du}{dt} = \frac{\partial u}{\partial x_1}\cdot\frac{dx_1}{dt} + \frac{\partial u}{\partial x_2}\cdot\frac{dx_2}{dt} + \cdots + \frac{\partial u}{\partial x_n}\cdot\frac{dx_n}{dt}$$

(8 Marks)

(b) If $x = r\cos\theta,\ y = r\sin\theta$ then show that

$$\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2} = 0$$

(8 Marks)

(c) If K is the area of a triangle with sides a, b, c, show that

$$\left(\frac{\partial K}{\partial a}\right)_{b,c} = \frac{a}{2}\ Cot\ A$$

(8 Marks)



## QUESTION FIVE (24 MARKS)

(a) Find a point within a triangle such that the sum of the squares of its distances from the three verticies is minimum. (8 Marks)

(b) Prove that any square matrix can be expressed uniquely as the sum of a symmetric and a skew symmetric matrix. (6 Marks)

(c) Given matrix

$$A = \begin{bmatrix} 5 & 3 & 7 \\ 1 & 5 & 2 \\ 7 & 2 & 10 \end{bmatrix}$$

Find Adj (A) and hence solve the system of equations:

$$5x + 3y + 7z = 4$$
$$x + 5y + 2z = 2$$
$$7x + 2y + 10z = 5$$

By using matrix method. (10 Marks)

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# UNIVERSITY OF NAIROBI

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FME 371: MECHANICAL ENGINEERING
FGE 381: GEOSPATIAL ENGINEERING

ENGINEERING MATHEMATICS III

DATE: 7 FEBRUARY 2011 TIME: 11.15 A.M - 1.15 P.M.

INSTRUCTIONS
Answer Question ONE and TWO other Questions.

QUESTION ONE (32 MARKS)

(a) Prove that

(i) $\nabla(F+G) = \nabla F + \nabla G$

(ii) $\nabla(FG) = F\nabla G + G\nabla F$

Where F and G are scolars. (7 Marks)

(b) If $u = \frac{y}{z} + \frac{z}{x} + \frac{x}{y}$, show that $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} + z\frac{\partial u}{\partial z} = 0$ (6 Marks)

(c) Express $\nabla\phi$ in orthogonal curvilinear coordinate system. (7 Marks)



$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ 0 & -\frac{\sqrt{3}}{2} & -\frac{1}{2} \end{bmatrix}$$ orthogonal?

(6 Marks)

(e) If

$z_1 = f_1(x_1)$
$z_2 = f_2(x_1, x_2)$
$z_3 = f_3(x_1, x_2, x_3)$
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$z_n = f_n(x_1, x_2, \ldots\ldots x_n)$

then prove that

$$\frac{\partial(z_1, z_2, \ldots\ldots, z_n)}{\partial(x_1, x_2, \ldots\ldots x_n)} = \frac{\partial z_1}{\partial x_1} \cdot \frac{\partial z_2}{\partial x_2} \cdots\cdots \frac{\partial z_n}{\partial x_n}$$

(6 Marks)

QUESTION TWO (24 MARKS)

(a) Verify Green's theorem in the plane for

$$\oint_c \left(xy + y^2\right)dx + x^2 dy$$

where c is a closed curve of the region bounded by $y = x$ and $y = x^2$

(8 Marks)

(b) If $\vec{r} + x\hat{i} + y\hat{j} + z\hat{k}$ then prove

(i) $\nabla^2\left(\frac{1}{r}\right) = 0$ (ii) $\nabla \cdot \left(\frac{\vec{r}}{r^3}\right) = 0$



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b) Show that in orthogonal curvilinear coordinate system

i) $\nabla.(A_1 \hat{e}_1) = \dfrac{1}{h_1 h_2 h_3} \dfrac{\partial}{\partial u} (A_1 h_2 h_3)$

ii) $\nabla X (A_1 \hat{e}_1) = \dfrac{\hat{e}_2}{h_3 h_1} \dfrac{\partial}{\partial u_3} (A_1 h_1) - \dfrac{\hat{e}_3}{h_1 h_2} \dfrac{\partial}{\partial u_2} (A_1 h_1)$ (10 marks)

c) If $\vec{A} = (3x^2 + 6y)\hat{i} - 14yz\hat{j} + 20xz^2 k$, evaluate $\int_c \vec{A}.d\vec{r}$ from (0, 0, 0) to (1, 1, 1) along the path c given as $x = t, y = t^2, z = t^3$. (6 marks)

**Question 4 (24 marks)**

a) If $u = (x, y)$, where $x = \Phi(t)$ and $y = \varphi(t)$, then prove that

$$\frac{du}{dt} = \frac{\partial u}{\partial x} \cdot \frac{dx}{dt} + \frac{\partial u}{\partial y} \frac{dy}{dt}.$$ (8 marks)

b) If $x = r\cos\theta$, $y = r\sin\theta$, then show that

$$\frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} = 0$$ (8 marks)

c) Find a point within a triangle such that the sum of the squares of its distances from the three verticies is minimum. (8 marks)

**Question 5 (24 marks)**

a) If k is the area of a triangle with sides a,b,c show that

$$\left(\frac{\partial k}{\partial a}\right)_{b,c} = \frac{a}{2}\cot A$$ (7 marks)



b) Given matrix

$$A = \begin{bmatrix} 2 & -2 & 4 \\ 2 & 3 & 2 \\ -1 & 1 & -1 \end{bmatrix},$$ find $Adj(A)$ and solve the system of equations

$$2x - 2y + 4z = -12$$

$$2x + 3y + 2z = 8$$

$$-x + y - z = 7/2$$

by using matrix method. (10 marks)

c) Prove that any square matrix can uniquely be expressed as the sum of a symmetric an a skew symmetric matrix. (7 marks)

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FGE 371: GEOSPATIAL ENGINEERING

ENGINEERING MATHEMATICS III

DATE: 8TH FEBRUARY 2010 TIME: 11.15 – 1.15 P.M.

INSTRUCTIONS
Answer question ONE and TWO other questions.

QUESTION 1 (32 MARKS)

(a) Prove that

(i) $\nabla\cdot(\vec{A}+\vec{B}) = \nabla.\vec{A} + \nabla.\vec{B}$

(ii) $\nabla\cdot(\phi\vec{A}) = \nabla\phi.\vec{A} + \phi\nabla.\vec{A}$

Where $\vec{A}$ and $\vec{B}$ are vectors and $\phi$ is scalar (7 Marks)

(b) If $u = F(x-y,\ y-z,\ z-x)$ prove that

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = 0$$ (6 Marks)

(c) Express Green's theorem in the plane in vector notation. (7 Marks)



(d) If $u, v$ are functions of $r, s$ and $r, s$ are functions of $x, y$ then prove that:

$$\frac{\partial(u,v)}{\partial(x,y)} = \frac{\partial(u,v)}{\partial(r,s)} \cdot \frac{\partial(r,s)}{\partial(x,y)}$$

(e) Is matrix

$$\begin{pmatrix} \frac{1}{3} & \frac{2}{3} & \frac{2}{3} \\ \frac{2}{3} & \frac{1}{3} & -\frac{2}{3} \\ \frac{2}{3} & -\frac{2}{3} & \frac{1}{3} \end{pmatrix}$$

orthogonal? (6 Marks)

QUESTION 2 (24 MARKS)

(a) Find the work done in moving a particle in a force field given by:

$$\vec{F} = 3xy\hat{i} - 5z\hat{j} + 10x\hat{k}$$

along the curve $x = t^2 + 1,\ y = 2t^2,\ z = t^3$ from $t = 1$ to $t = 2$. (8 Marks)

(b) Prove Green's theorem in the plane if C is a closed curve which has the property that any straight line parallel to the coordinate axes cuts C in almost two points. (8 Marks)

(c) If $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ then prove that:

(i) $\nabla^2\left(\frac{1}{r}\right) = 0$

(ii) $\Delta\cdot\left(\frac{\vec{r}}{r^3}\right) = 0$

(8 Marks)

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(8 Marks)

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