THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATION 2007

322 STRATIGRAPHY AND REMOTE SENSING (THEORY P.1)

322 STRATIGRAPHY AND REMOTE SENSING (PRACTICAL P.2)

335 STRUCTURAL GEOLOGY (THEORY P.1)

335 STRUCTURAL GEOLOGY (PRACTICAL P.2)

402 GEOLOGY IN ZAMBIA

442 ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS (THEORY, P.1).

319 COMPUTER TECHNIQUES

322 STATISTICS AND COMPUTER APPLICATION

455 OPERATIONS RESEARCH

562 INVESTMENT ANALYSIS

595 MINERAL PRODUCTION CONTROL

M 205 INTRODUCTION TO METALLURGY 1

M 332 CHEMICAL THERMODYNAMICS 2

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M 442 HYDROMETALLURGY

M 442 PHYSICAL HYDROMETALLURGY

17. MM 452 PROCESS CONTROL AND INSTRUMENTATION

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19. MM 552 PROCESS DESIGN

20. MM 562 FOUNDRY

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

GG322: STRATIGRAPHY AND REMOTE SENSING

PRACTICAL

PAPER II

TIME: THREE HOURS
ANSWER: ALL QUESTIONS. NEATLY DRAWN SKETCHES/ DIAGRAMS RECOMMENDED FOR A FULL MARK.

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1 (a) What does following abbreviations stand for?
- (i) UTM (2 marks)
- (ii) TIFF (2 marks)
- (iii) EMR (2 marks)
- (iv) GPS (2 marks)

(b) Differentiate between the following:
- (i) TIFF and GeoTIFF ..... (4 marks)
- (ii) Spectral Signature and Spectral Response ..... (4 marks)
- (iii) Path and Row..... (4 marks)
- (iv) Cross-track and Along-track scanners..... (4 marks)

(c) With neatly labeled sketches, where possible differentiate between the following:
- (i) Vector Model and Raster Model (4 marks)
- (ii) Aerial photographs and satellite images (4 marks)
- (iii) Transmission and Reflection (4 marks)
- (iv) Passive and Active Sensors (4 marks)
- (v) Energy and Radiation (4 marks)

2. (a) List the sensor systems known today ..... (5 marks)
(b) How many satellites are required to get an accurate GPS position? Explain your answer.....(4 marks)
(c) In what ways can you improve accuracy in a GPS set-up?..... (2 marks)
(d) List the data sources i.e. various forms of data that you could enter into a GIS project .....(5 marks)

3. As a Geologist, you have been assigned to undertake a research study in Zambia.

(a) You decide to select 2 aerial photos so that you can undertake an initial photo-geological interpretation. You are therefore required to:

(i) Provide a fully annotated photogeological interpretation on the portion that you are able to obtain a stereo vision i.e. able to see in three dimensions. .....(30 marks)

(ii) Provide a description of the photogeology i.e. the geology of the annotated area.....(10 marks)

END -- GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – FEBRUARY 2008

GG335 – STRUCTURAL GEOLOGY I

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) State the six characteristics of elasticity
(b) Illustrate in form a well labelled diagram the law of elasticity.
(d) What is rheology and on which extrinsic and intrinsic conditions does it depend?
(e) State the equation that relates stress to strain, clearly defining the various parameters and units.

Q2. (a) What are tectonites?
(b) Write short notes on the following:
(i) S-tectonites
(ii) L-tectonites
(iii) S-L tectonites
(c) Describe how foliation forms
(d) What is an unconformity and what does it represent?

Q3. (a) Define the following:
(i) Fold limb
(ii) Fold wavelength
(iii) Fold amplitude
(ii) Fold height
(iii) Fold crest
(iv) Fold trough
(v) Axial plane
(vi) Hinge
(vii) Dome
(b) Name and briefly describe three types of folds on the basis of the orientation of a hinge line.
(c) Name and describe briefly four types of folds on the basis of the orientation of an axial plane.

Q4. (a) Distinguish between:
(i) Anticline and syncline
(ii) Symmetrical folds and asymmetrical folds
(b) Define the following:
(i) Parallel folds
(ii) Similar folds
(iii) Concentric folds
(iv) Angular folds
(c) For the following interlimb angles name the corresponding fold types: (i) 180-120°, (ii) 120-70°, (iii) 70-30°, (iv) 30-0°, (v) 0°

Q5. (a) Distinguish between a fault and a joint.
(b) Define the following:
(i) Fault Plane

(ii) Hangingwall
(iii) Footwall
(iv) Dip
(v) Strike

(c) Write brief notes on the following (use sketches for full marks):
(i) Normal fault
(ii) Reverse fault
(iii) Left handed strike slip fault
(iv) Oblique slip fault

(d) Describe the following (use sketches for full marks):
(i) Throw
(ii) Heave

Q6. (a) What is a parasitic fold?

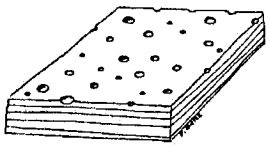
(b) On an antiform where would you expect m-shaped, z-shaped and s-shaped parasitic folds to occur (illustrate)

(c) Define vergence.

(d) Write short notes on the following types of joints
(i) Tectonic joints
(ii) Columnar jointing
(iii) Exfoliation joints
(iv) Mudcrack joints

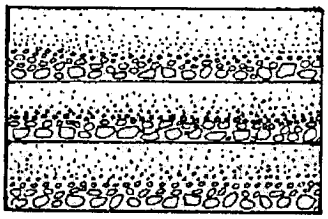
(e) What is a vein and how does it form.

Q7. (i) Name and describe the structures illustrated in the diagrams below. How does each one of them form?



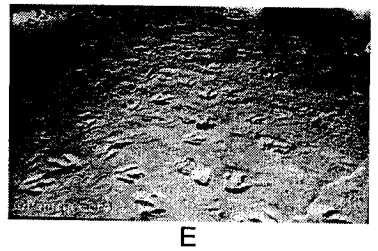
A

B



C

D



E

(ii) What are the above structures generally called and why?

----------Good Luck!!!----------

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – FEBRUARY 2008

GG335 - STRUCTURAL GEOLOGY
PAPER II - PRACTICAL

INSTRUCTIONS: Answer all questions
TIME: Two and Half Hours

Q1. Refer to Map 1. Do the following (30 marks):
(a) With reason(s) identify whether the strata are vertical, inclined or horizontal.
(b) Draw a geological cross-section A-B using a scale of 1cm to 200 m.
(c) Describe the geological history of the area
(d) Determine the true thicknesses of the various rock units.

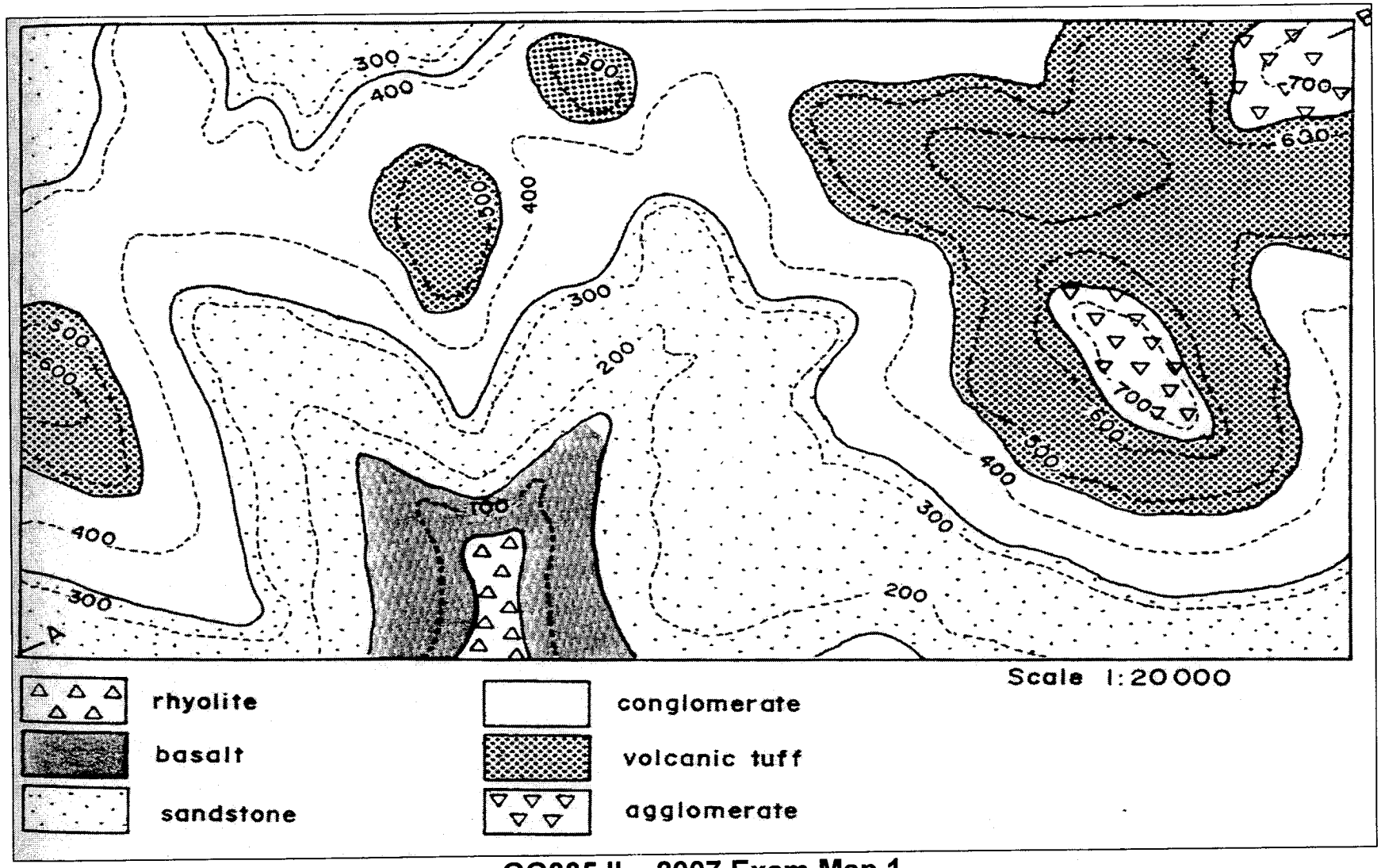
Q2 You are provided with Map 2, do the following (10 marks):
(a) Name, with reason(s), the structures A-G (you need to be very specific)
(b) Write a geological history of the area

Q3. During a mapping exercise the following structural data (i.e. dip, dip direction of foliation, fault and joint surfaces as well as in some cases trend and plunge of linearments) (24 marks):

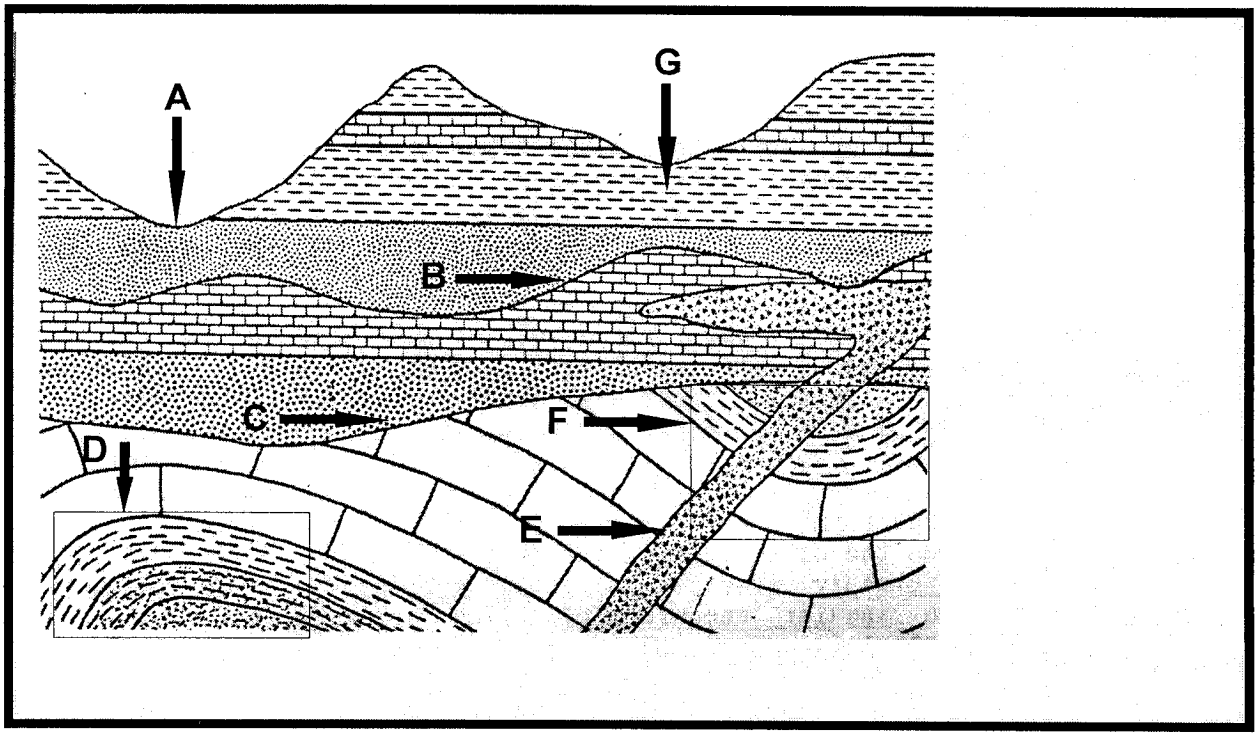
STRUCTURE	DIP (OR PLUNGE) (0°)	DIP DIRECTION (0°)
Bedding	37	225
	27	240
	13	310
Intersection line between axial surface and bedding	13	114
	17	301
	20	297

Q4. Two bedding surfaces with attitudes 320/24°NE & 230/50°NW and two fault surfaces with attitudes 020/35°NW & 290/10°SW are observed in a rock outcrop and measured: Plot these surfaces on a single stereonet and determine attitudes for all the intersection lines. By plotting poles to all the planes determine the acute and obtuse angles between all intersecting planes (16 marks).

----------Good Luck!!----------



GG335 II – 2007 Exam Map 1



GG335 II – 2007 Exam Map 2

UNIVERSITY OF ZAMBIA
GEOLOGY DEPARTMENT

SECOND SEMESTER EXAMINATIONS: FEBRUARY 2008

GG402: GEOLOGY OF ZAMBIA

TIME: 3 HOURS
INSTRUCTIONS: ANSWER BOTH QUESTIONS IN SECTION 1 AND ANY TWO FROM SECTION 2. **SKETCHES AND DIAGRAMS ARE IMPORTANT FOR A FULL MARK**

SECTION 1

1. In the Table below. Fill in the blank spaces – 30 marks.

Geologic Time	Known Tectonic Event	Age Range	Structural Trend	Rock Types	Known Economic Minerals
Proterozoic	Lufilian Arc				
	Zambezi Belt				
	Mozambique Belt				
	Irumide Belt				
	Ubendian Belt				
Archean					

2. Draw a NEAT sketch map of Southern Africa showing Cratons and the Major Structural features that affected the deposition of sediments and shaped the Geology of Zambia. Indicate the boundary of Zambia on your Sketch..... 30 marks

SECTION 2

3. (i) What is the Lufilian Arc famous for?
   (ii) Discuss the evidence for existence of the Lufilian Arc on the Zambian and DRC Copperbelt?
   (ii) Outline the regional setting, and tectonism that affected the Lufilian Arc.
   .....20 marks

4. In form of a Table give the Stratigraphy of the Karoo Supergroup in Zambia indicating the following:
   (i) Thickness of each formation
   (ii) Predominant rock types
   (iii) Depositional environment
   (iv) Economic Potential .....20 marks

5. Write Short Notes on any Five (5) of the following:
   (i) Greenstone Belts
   (ii) Archean Terranes
   (iii) Orogenic cycles
   (iv) Tanzania Craton
   (v) Distinguishing features of the Archean-Proterozoic boundary
   (vi) The Archean Tectonic Model
   (vii) Characteristics of Archean rocks .....20 marks

6. The President of Zambia announced that soil samples analysed for oil and gas in Northwestern Province have proved positive. Discuss the possibility of finding oil in Zambia with a focus on:
   (i) presence of sedimentary basins in Zambia
   (ii) Geology of these sedimentary basins in terms of source rocks, reservoirs and traps for oil.....20 marks

END ---

GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – FEBRUARY 2008

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS

PAPER I – THEORY

INSTRUCTIONS: Answer any fOUR questions. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) Define the following terms:
- (i) Mineral Deposit
- (ii) Grade
- (iii) Cut-off-grade
- (iv) Anisotropism
- (v) Scratch Hardness

(b) Describe how the following ore textures are formed: (i) Cumulus textures, (ii) Exsolution textures, (iii) Replacement textures, (iv) Intergranular textures

(c) Name the four stable isotopes commonly used in studying ore deposits and state the general formular used in the calculation of delta values and the unit of measure.

(d) Distinguish between syngenesis and epigenesis.

(e) Classify the following deposit types into either syngenetic or epigenetic: Porphyry, Skarn, Vein, Volcanogeneic Massive Sulphide, Sedimentary Massive Sulphide, Magmatic and Placer.

Q2. (a) Distinguish between stratabound and stratiform deposits.

(b) The Zambian Copperbelt Deposits are believed to be stratiform why?

(c) Discuss briefly how the Zambian Copperbelt Deposits are believed to have formed paying attention to the source of the so much copper in the sediments, how this copper was transported and how it got deposited.

(d) If you did a mass balance of the copper in the sediments and that in the Basement, would you conclude that two are the same? Why or why not?

Q3. (a) Define the term porphyritic.

(b) Porphyry deposits are important sources of three important metals. What are these metals?

(c) What two tectonic environments are porphyry deposits associated with?

(d) In Zambia there are several orogenic belts of Pan African age and yet we have not heard of any discovery of porphyry deposits. Why is this so?

(e) What mineralogy characterizes the following porphyry alteration zones:
- (i) Propyllitic
- (ii) Phyllic

(iii) Potassic

(f) Briefly discuss how porphyry deposits form.

Q4. (a) Several theories have been advanced in the last 100 years or so to explain the origin of ore deposits. In terms of magmatic segregation two processes have been postulated to explain the origin of chromite and Cu-Ni orebodies. These are fractional crastallization and liquid immiscibility, respectively. Describe the nature of these two processes and give one example deposit resulting from each deposit.

(b) Distinguish between startiform and podiform chromite deposits.

Q5. (a) What is a hydrothermal solution?

(b) Name the three main types of hydrothermal solutions and how each one of them is derived.

(c) Define the following terms:

(i) Epithermal Vein

(ii) Mesothermal Vein

(iii) Hypothermal Vein

(d) How in general terms do veins form?

(e) A vein deposit with copper mineralization has been discovered through exploration and needs to be evaluated. This vein deposit, containing quartz, pyrite and chalcopyrite, is vertical. Discuss the main features that the vein would acquire after oxidation has occurred and how these features are acquired.

Q6. Banded Iron Formations (or BIFs) globally are important sources of iron for use in the production of steel. Describe BIFs in terms of age, tectonic setting, mode of occurrence and how they formed.

----------Good Luck!!!----------

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MG 319 – COMPUTER TECHNIQUES

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS.

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1. (a) Explain the meaning of the terms Byte, Int, and Long. How is addressing accomplished in storing data and information in computing.

   (b) What is "concantenation" and what symbol is adopted for its use?

   (c) What is an "identifier" and how many forms might it assume?

2. (a) Define the meaning of the term "structured programming" and mention the categories associated with this way of solving problems.

   (b) What is a "Java Virtual Machine" ?

   (c) Explain the possibility of combining different pieces of "byte code" from many sources into one single programme.

3. Examine the following codes for a variable called "ConcGrade"

```
if ((ConcGrade > min) && (ConcGrade < max ))
System.out.println ("concentrate grade is OK");
else
System.out.println ("warning: concentrate grade is out of range")
```

   (a) What are the expressions in brackets called and the meaning of the symbols && ?

   (b) Re-write the above code using the | | symbols and using the variable "ConcGrade" and "Recovery" and suggest what the output must be using the "if...else" statement.

4. (a) If you were writing a programme that was computing resource estimation for a particular deposit containing three types of minerals that you are evaluating but have forgotten to take into account a parameter for one of the minerals. Your programme will contain an error, what kind of programme error is it?

(b) Show the declaration of two variables called *metres* and *flowRate* as integer and double respectively and initialise them to 0 and 50.56 respectively in the declaration.

5. (a) Complete the following programme and give it any name as your first programme. Suggest what should be where the ??? marks exist.

```
public class ???
{
 public static void main(String[] args)
{
System.out.println("Hello out there.");
System.out.println("Would you like to join the computing class?");
System.out.println("Answer y for yes or n for no.");
char answerLetter;
??? = Keyboard.readLineNonwhiteChar();
if (answerLetter == 'y')
System.out.println("???.");
System.out.println("???.");
System.out.println("Press enter key to end program.");
```

(b) (i) What is the code "public static void main(String[] args)" known as?

(ii) Why are the phrases in the print commands in inverted commas?

(iii) You interact with the programme using the keyboard, how is it referred to in the programme and what is it called?

END OF EXAMINATION IN MG 319

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER UNIVERSITY EXAMINATIONS – 2008

MI 322 – STATISTICS AND COMPUTER APPLICATION

TIME: 3 HOURS **FULL MARKS: 100**

INSTRUCTIONS: Answer question 1 and any 4 questions

Question 1

a) Barloworld Ltd sells three types of mining equipment: front end loaders; dump trucks and excavators. Of its equipment sales 50% are front end loaders (the least expensive), 30% are dump trucks and 20% are excavators. Each manufacturer offers a 1-year warranty on parts and labour. It known that 25% of front end loaders require warranty repair work, where as the corresponding percentages for dump trucks and excavators are 20% and 10%, respectively.

i) What is the probability that a randomly selected purchaser has bought a front end loader that will need repair while under warrant?

[5 Marks]

ii) What is the probability that a randomly selected purchaser has equipment that will need repair while under warranty?

[5 Marks]

iii) If a customer returns to Barloworld Ltd with equipment that needs warranty repair work, what is the probability that the equipment is a front end loader? A dump truck? An excavator?

[5 Marks]

b) The production time for samples of components produced in 2 different factories are recorded as:

Factory A	11.3	9.9	13.1	8.0	10.8	11.7
Factory B	11.0	11.2	12.5	13.3	12.4	11.8

i) Calculate the mean and standard deviation of production time at each factory and hence comment on the comparative merits of two factories

[3 Marks]

ii) Under what conditions would it be meaningful to produce a scatter plot of data?

[2 Marks]

Question 2

a) **50** KCM miners were questioned about the number of hours they sleep each day. We want to test the hypothesis that the miners need less sleep than the general public which needs an average of **7.7** hours of sleep.

i) Compute a rejection region for a significance level of .05.

[5 Marks]

ii) If the sample mean is 7.5 and the standard deviation is .5, what can you conclude?

[5 Marks]

b) Mopani cobalt plant has kept records of on-the-job accidents for many years. Accidents are reported according to which hour of an 8-hour shift they happen. The following table shows their accident report.

Hour of Shift	# of Accidents
1	19
2	17
3	15
4	24
5	20
6	26
7	22
8	25
Total	168

The Mine Workers Union of Zambia based at Mopani Head office wants to know whether accidents are more likely to take place during one hour of the shift rather than another. They are asking you for an expert opinion. Do you think that more accidents are likely to take place during one hour of a shift over another?

[10 Marks]

Question 3

A task force committee of 3 members at Mopani Copper mines Plc is to be formed consisting of one representative each from the Miners Union of Zambia (MUZ), Senior Management and the Ministry of Mines and Minerals Development (MMD). If there are 3 possible representatives from MUZ, 2 from Management and 4 from MMD, determine how many different committees can be formed, using

a) The fundamental principle of counting and **[5 Marks]**
b) A tree diagram. **[15Marks]**

Question 4

The Parts Manager of company **X** that specialises in drilling accessories tallied the number of enquiries that he received from mining companies over a **50** day period. He found that the mean number per day for this period was **45** with a standard deviation of 8. Construct a **95%** confidence interval for the true mean. Write a sentence that explains your findings.

[20 Marks]

Question 5

Data was collected from open pit drivers to study the effect of a sleep suppressant on reaction time. Forty participants were given various amounts of the suppressant and then took a test to see how many milliseconds it took to press a button upon seeing headlights of the trucks. The scatter diagram is shown in figure 5.1

A. Given an approximate equation of the regression line. Interpret the slope and the y- intercept.

[10 Marks]

B. Give an approximation of the correlation coefficient. Explain, using a complete sentence, why you chose this number.

[10 Marks]

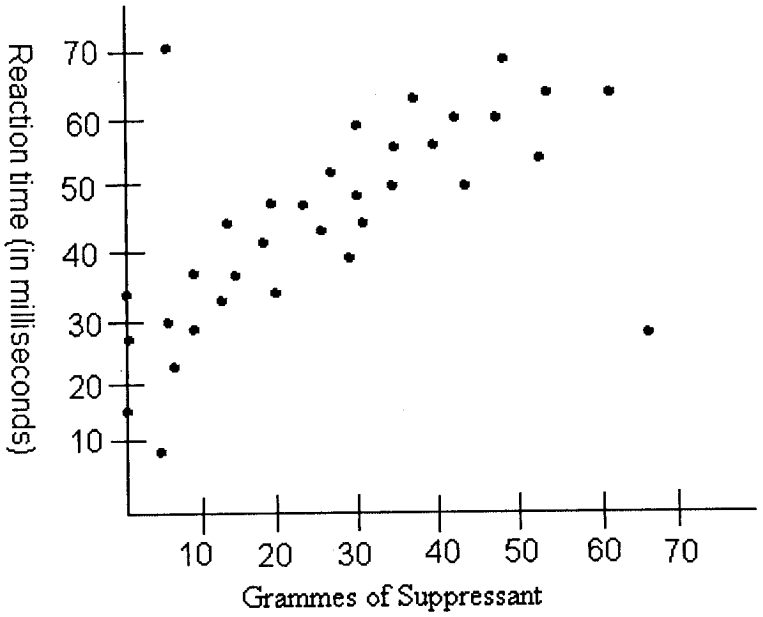


Fig. 5.1 Study of reaction time

Question 6

a) The mean height of male students at the University of Zambia (in cm) is 175 and Variance is 64. For girls, the mean is 165 and the variance is 64. If 8 male and 8 female students were sampled what is the probability the mean height of the sample of female students would be higher than the mean height of male students?

[15Marks]

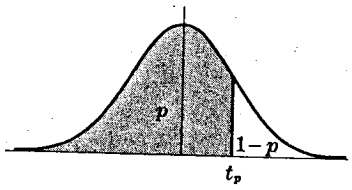
b) If a test is normally distributed with a mean of 60% and standard deviation of 10%, what proportion of scores are above 85%?

[5 Marks]

.....END OF EXAMINATION.....

Appendix D

Percentile Values (t_p)
for
Student's t Distribution
with ν Degrees of Freedom

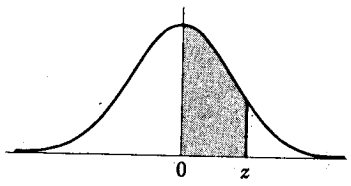


ν	$t_{.55}$	$t_{.60}$	$t_{.70}$	$t_{.75}$	$t_{.80}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$
1	.158	.325	.727	1.000	1.376	3.08	6.31	12.71	31.82	63.66
2	.142	.289	.617	.816	1.061	1.89	2.92	4.30	6.96	9.92
3	.137	.277	.584	.765	.978	1.64	2.35	3.18	4.54	5.84
4	.134	.271	.569	.741	.941	1.53	2.13	2.78	3.75	4.60
5	.132	.267	.559	.727	.920	1.48	2.02	2.57	3.36	4.03
6	.131	.265	.553	.718	.906	1.44	1.94	2.45	3.14	3.71
7	.130	.263	.549	.711	.896	1.42	1.90	2.36	3.00	3.50
8	.130	.262	.546	.706	.889	1.40	1.86	2.31	2.90	3.36
9	.129	.261	.543	.703	.883	1.38	1.83	2.26	2.82	3.25
10	.129	.260	.542	.700	.879	1.37	1.81	2.23	2.76	3.17
11	.129	.260	.540	.697	.876	1.36	1.80	2.20	2.72	3.11
12	.128	.259	.539	.695	.873	1.36	1.78	2.18	2.68	3.06
13	.128	.259	.538	.694	.870	1.35	1.77	2.16	2.65	3.01
14	.128	.258	.537	.692	.868	1.34	1.76	2.14	2.62	2.98
15	.128	.258	.536	.691	.866	1.34	1.75	2.13	2.60	2.95
16	.128	.258	.535	.690	.865	1.34	1.75	2.12	2.58	2.92
17	.128	.257	.534	.689	.863	1.33	1.74	2.11	2.57	2.90
18	.127	.257	.534	.688	.862	1.33	1.73	2.10	2.55	2.88
19	.127	.257	.533	.688	.861	1.33	1.73	2.09	2.54	2.86
20	.127	.257	.533	.687	.860	1.32	1.72	2.09	2.53	2.84
21	.127	.257	.532	.686	.859	1.32	1.72	2.08	2.52	2.83
22	.127	.256	.532	.686	.858	1.32	1.72	2.07	2.51	2.82
23	.127	.256	.532	.685	.858	1.32	1.71	2.07	2.50	2.81
24	.127	.256	.531	.685	.857	1.32	1.71	2.06	2.49	2.80
25	.127	.256	.531	.684	.856	1.32	1.71	2.06	2.48	2.79
26	.127	.256	.531	.684	.856	1.32	1.71	2.06	2.48	2.78
27	.127	.256	.531	.684	.855	1.31	1.70	2.05	2.47	2.77
28	.127	.256	.530	.683	.855	1.31	1.70	2.05	2.47	2.76
29	.127	.256	.530	.683	.854	1.31	1.70	2.04	2.46	2.76
30	.127	.256	.530	.683	.854	1.31	1.70	2.04	2.46	2.75
40	.126	.255	.529	.681	.851	1.30	1.68	2.02	2.42	2.70
60	.126	.254	.527	.679	.848	1.30	1.67	2.00	2.39	2.66
120	.126	.254	.526	.677	.845	1.29	1.66	1.98	2.36	2.62
∞	.126	.253	.524	.674	.842	1.28	1.645	1.96	2.33	2.58

Source: R. A. Fisher and F. Yates, *Statistical Tables for Biological, Agricultural and Medical Research*, published by Longman Group Ltd., London (previously published by Oliver and Boyd, Edinburgh), and by permission of the authors and publishers.

Appendix C

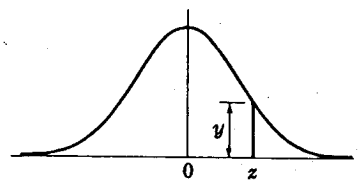
Areas under the Standard Normal Curve from 0 to z



z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
3.6	.4998	.4998	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.7	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.8	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.9	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000

Appendix B

Ordinates (y) of the Standard Normal Curve at z



z	0	1	2	3	4	5	6	7	8	9
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0.1	.3970	.3965	.3961	.3956	.3951	.3945	.3939	.3932	.3925	.3918
0.2	.3910	.3902	.3894	.3885	.3876	.3867	.3857	.3847	.3836	.3825
0.3	.3814	.3802	.3790	.3778	.3765	.3752	.3739	.3725	.3712	.3697
0.4	.3683	.3668	.3653	.3637	.3621	.3605	.3589	.3572	.3555	.3538
0.5	.3521	.3503	.3485	.3467	.3448	.3429	.3410	.3391	.3372	.3352
0.6	.3332	.3312	.3292	.3271	.3251	.3230	.3209	.3187	.3166	.3144
0.7	.3123	.3101	.3079	.3056	.3034	.3011	.2989	.2966	.2943	.2920
0.8	.2897	.2874	.2850	.2827	.2803	.2780	.2756	.2732	.2709	.2685
0.9	.2661	.2637	.2613	.2589	.2565	.2541	.2516	.2492	.2468	.2444
1.0	.2420	.2396	.2371	.2347	.2323	.2299	.2275	.2251	.2227	.2203
1.1	.2179	.2155	.2131	.2107	.2083	.2059	.2036	.2012	.1989	.1965
1.2	.1942	.1919	.1895	.1872	.1849	.1826	.1804	.1781	.1758	.1736
1.3	.1714	.1691	.1669	.1647	.1626	.1604	.1582	.1561	.1539	.1518
1.4	.1497	.1476	.1456	.1435	.1415	.1394	.1374	.1354	.1334	.1315
1.5	.1295	.1276	.1257	.1238	.1219	.1200	.1182	.1163	.1145	.1127
1.6	.1109	.1092	.1074	.1057	.1040	.1023	.1006	.0989	.0973	.0957
1.7	.0940	.0925	.0909	.0893	.0878	.0863	.0848	.0833	.0818	.0804
1.8	.0790	.0775	.0761	.0748	.0734	.0721	.0707	.0694	.0681	.0669
1.9	.0656	.0644	.0632	.0620	.0608	.0596	.0584	.0573	.0562	.0551
2.0	.0540	.0529	.0519	.0508	.0498	.0488	.0478	.0468	.0459	.0449
2.1	.0440	.0431	.0422	.0413	.0404	.0396	.0387	.0379	.0371	.0363
2.2	.0355	.0347	.0339	.0332	.0325	.0317	.0310	.0303	.0297	.0290
2.3	.0283	.0277	.0270	.0264	.0258	.0252	.0246	.0241	.0235	.0229
2.4	.0224	.0219	.0213	.0208	.0203	.0198	.0194	.0189	.0184	.0180
2.5	.0175	.0171	.0167	.0163	.0158	.0154	.0151	.0147	.0143	.0139
2.6	.0136	.0132	.0129	.0126	.0122	.0119	.0116	.0113	.0110	.0107
2.7	.0104	.0101	.0099	.0096	.0093	.0091	.0088	.0086	.0084	.0081
2.8	.0079	.0077	.0075	.0073	.0071	.0069	.0067	.0065	.0063	.0061
2.9	.0060	.0058	.0056	.0055	.0053	.0051	.0050	.0048	.0047	.0046
3.0	.0044	.0043	.0042	.0040	.0039	.0038	.0037	.0036	.0035	.0034
3.1	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026	.0025	.0025
3.2	.0024	.0023	.0022	.0022	.0021	.0020	.0020	.0019	.0018	.0018
3.3	.0017	.0017	.0016	.0016	.0015	.0015	.0014	.0014	.0013	.0013
3.4	.0012	.0012	.0012	.0011	.0011	.0010	.0010	.0010	.0009	.0009
3.5	.0009	.0008	.0008	.0008	.0008	.0007	.0007	.0007	.0007	.0006
3.6	.0006	.0006	.0006	.0005	.0005	.0005	.0005	.0005	.0005	.0004
3.7	.0004	.0004	.0004	.0004	.0004	.0004	.0003	.0003	.0003	.0003
3.8	.0003	.0003	.0003	.0003	.0003	.0002	.0002	.0002	.0002	.0002
3.9	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0001	.0001

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER UNIVERSITY EXAMINATIONS - 2008

MI 455: OPERATIONS RESEARCH

TIME: 3 HOURS **FULL MARKS: 100**

INSTRUCTIONS: ANSWER ONLY FIVE QUESTIONS

1. A mine development project has the following three PERT time estimates with event 1 being the starting point of the project and event 8 the end:

Activity	a	m	b
1,2	1	2	6
1,3	3	4	6
2,4	3	5	6
2,5	3	4	6
3,7	5	6	7
4,6	1	3	4
5,6	2	3	5
5,7	2	2	3
6,7	3	5	7
6,8	1	2	4
7,8	2	3	4

Key: a = optimistic time m = most likely time b = pessimistic time

(i) Construct the arrow diagram for the project **[3 points]**

(ii) Using PERT assumptions, find the mean and variance of times of each activity **[3 points]**

(iii) Find the critical path using the mean times in (ii) above **[8 points]**
Assume the completion time for the total project can be estimated by a normal distribution with the following parameters:
ΣX = sum of means along the critical path
ΣS = sum of variances along the critical path

(iv) Determine these two parameters **[2 points]**

(v) If you had to estimate a time for project completion and wanted to be 95% confident of completion by this time, what would be your estimate?
[4points]

2. A coal mine has two production shafts A and B. Production statistics for each shaft are as follows:

	Shaft A	**Shaft B**
Hoisting capacity, t/day	4,000	3,000
Mining output, t/manshift	20	28
Haulage performance, t/unit/shift	300	190

The underground force operates on a two shifts per day basis. Production miners are restricted to 120 per day.

Haulage fleet in the mine consists of 10 units. However, since the shafts are close together, a unit can work a portion of a shift at another shaft without loss of production. Mill capacity including surface bin is limited to 5,000 tonnes per day. Profit per tonne averages $2.00 for production from Shaft A and $3.00 from Shaft B.

If the objective is to maximize profit:

(i) Formulate the linear programming model for this mine **[5 points]**
(i) Determine the maximum daily profit **[5 points]**
(ii) Find the number of tonnes to mine daily from each shaft **[5 points]**
(iii) Determine the best allocation of resources for each shaft **[5 points]**

3. A mine project management team has determined that the three key variables in the operations of the company are Sales Quantity, Selling Price and Total Operating Costs. A detailed study of these three parameters has resulted in the following probability estimates of levels of activity for the next year.

Sales Price($/unit)	Probability (P)
20	0.1
22	0.2
24	0.3
28	0.3
Total	1.00

Total Operating Costs $	Probability P(C)
100,000	0.3
125,000	0.4
150,000	0.3
Total	1.00

You are required to:

(i) Determine the Expected Value of each of the parameters **[2 points]**
(ii) Determine the Expected Value of Net Profit. **[4 points]**
(iii) Use Monte Carlo simulation techniques and the following table of random numbers to simulate the Net Profit (ten simulations). **[5 points]**
(iv) What is the variance in the Net profit in (iii) above? **[5 points]**
(iv) From the simulation (assuming each of the ten outcomes has an equal probability of occurrence) determine the probability of obtaining a greater than $90,000 Net Profit. **[3 points]**

4. Consider the following mine transportation problem that has three shafts and four ore storage sites.

FROM/TO	Storage site 1	Storage site 2	Storage site 3	Storage site 4	Supply
Shaft 1	12	14	8	10	45
Shaft 2	7	16	11	9	60
Shaft 3	10	11	14	6	75
Demand	35	25	55	65	

(i) Find the initial feasible starting solution using the minimum cell cost and Northwest corner methods. Why is there a difference between the two solutions? **[10 points]**

(ii) From the minimum cell cost initial solution, determine the optimal solution using the stepping-stone method. **[10 points]**

Sales Quantity (units)	Probability P(Q)
5,000	0.1
7,500	0.3
10,000	0.4
12,000	0.2
Total	1.00

5. A mining section uses approximately 200,000 nuts and bolts per year. These nuts and bolts are purchased in standard package quantities of 5,000 at a cost of $50 per package. The storage costs of $0.10 per year to hold one bolt and nut are based on maximum inventory level. Interest and insurance charges are 13% of the average value of the inventory on hand. Typical order costs for preparing a purchase order, mailing, receiving, inspecting and transporting are $2,500 per each purchase. The company operates 250 days per year.

(i) What is the economic order quantity for this mine? **[10 points]**
(ii) What is the time interval between orders? **[10 points]**

6. A mine investor has on offer three mine investment opportunities. The various decisions, probabilities and outcomes are presented in the following table.

Decision (Purchase)	Returns ($)	
	Good economic conditions Probability 0.60	Poor economic conditions Probability 0.40
Gold mine	50,000	30,000
Gemstone mine	100,000	-40,000
Quarry for crushed stones	30,000	10,000

Furthermore, in the case of deciding to invest in the Gold mine and where the economic conditions are good, a further decision is made whether to sell the mine or not. If the mine is sold it will result in net payoff of $70,000. If it is not sold, under good economic conditions with a probability of 0.8, a payoff of $100,000 will be expected while under poor economic conditions with a probability of 0.2, the payoff will be $20,000.

(i) Construct the decision tree for the above investment decisions. **[10 points]**
(ii) Under these circumstances, what would be the best investment decision? **[10 points]**

END OF EXAMINATION

TABLE OF RANDOM NUMBERS

Sales Quantity Random Numbers	Sales Price Random Numbers	Total Cost Random Numbers
0.798	0.690	0.504
0.496	0.053	0.211
0.176	0.569	0.304
0.383	0.067	0.601
0.591	0.942	0.118
0.776	0.583	0.013
0.529	0.597	0.223
0.477	0.545	0.334
0.180	0.009	0.743
0.910	0.132	0.261

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER FINAL EXAMINATIONS - 2008

MI 562: INVESTMENT ANALYSIS

TIME: THREE (03) HOURS **FULL MARKS: 100**

INSTRUCTIONS:
ANSWER ALL QUESTIONS

1. i) State different types of risks you are likely to face when making investments. [5 Marks]

ii) Three investment have the following return characteristics:

i	*Pi*	*ri*
1	0.05	38%
2	0.2	23%
3	0.5	8%
4	0.2	-7%
5	0.05	-22%
Total	**1.0**	

i	*Pi*	*ri*
1	0.1	50%
2	0.2	30%
3	0.4	10%
4	0.2	-10%
5	0.1	-30%
Total	**1.0**	

i	*Pi*	*ri*
1	0.1	90%
2	0.25	50%
3	0.3	20%
4	0.25	-10%
5	0.1	-50
Total	**1.0**	

Key: i = investment
P_i= probability of investment achieving return r_i

(a) Calculate the expected returns standard deviation and variances [5 marks]

(b) Which one is the least risky and which one is most risky from their calculated expected returns, standard deviations, and variances?[5 marks]

2. You are a miner who has invested in a copper mine. The mine is small but has 1000 tonnes of copper which can be sold at K8000/tonne now. The proceeds of the sale are to be invested in a bank paying 6% per year annually for ten years.

i) If the economy is facing inflation at 10% per year is the purchasing power of your investment secured? [7 ½ marks]

ii) If you pay tax at 50% for the interest received is your investment still secure? [7 ½ marks]

3. Your company is offered a 20 percent interest in an operating gold mine for $8 million. The mine produces 30,000 ounces of gold per year and has an expected life of 10 years remaining, operating costs average $225 per ounce of gold produced and taxation payments average $125 per once. Your company's cost of capital is 10 percent.

What is the average price of gold over the remaining mine life required to economically justify the project? [5 marks]

If the gold price averages $675 per ounce, determine the payback period, equivalent annual return over the remaining mine life, net present value, present value ratio and rate of return associated with the investment. [15 marks]

1$=ZMK4, 000 use currency of your choice

4. You are evaluating two small mine investments A and B with the following cash flow profiles shown in the table below.

For what value of X are the following two cash flows equivalent at a 10% interest rate? [15 marks]

End of Year	0	1	2	3	4
Flow A, K	-10 000	5000	5000	5000	5000
Flow B, K	X	3500	4500	5500	6500

5. The executives of the Lumwana Copper Mines are trying to select the most economical feeder machine. Cash flows for the six available models are shown in the following table. The MARR is 8%.

(a) Compute the ROR for each alternative model. [6 marks]
(b) Determine which model should be purchased. [5 marks]

End of Year	A ZMK	B ZMK	C ZMK	D ZMK	E ZMK	F ZMK
0	-50 000	-100 000	-200 000	-220 000	-250 000	-380 000
1	13 190	37 185	74 386.40	74 386.40	82 693.50	128 485.60
2	13 190	37 185	74 386.40	74 386.40	82 693.50	128 485.60
3	13 190	37 185	74 386.40	74 386.40	82 693.50	128 485.60
4	13 190	37 185	74 386.40	74 386.40	82 693.50	128 485.60
5	13 190	37 185	74 386.40	74 386.40	82 693.50	128 485.60

(c)Which model should be purchased if there is a budget constraint of

(i) K280 000 [3 marks]
(ii) K230 000 [3 marks]
(iii) K210 000 [3 marks]

6. Mopani Copper Mine purchased a very specialized machine three years ago for K25 000. This machine is not readily saleable and assumed to have a zero salvage value. Operating costs are expected to be K10,000 next year, and to increase by K800 per year thereafter. The company has an opportunity to replace the existing machine with another specialized one that will cost K12 000. This machine has no salvage value, a useful life of 10 years, and operating costs of K5000 in the first year, with an annual increase of K1200 thereafter. If the MARR is 15%, should the company replace the old machine with the new one? [15 marks]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
SECOND SEMESTER UNIVERSITY EXAMINATIONS- 2008

MI 595 – MINERAL PRODUCTION CONTROL

TIME : THREE (3) HOURS FULL MARKS : 100

INSTRUCTIONS: Answer question **1** and any other **4** Questions

Question 1

Compute a production plan for extracting a portion of a level given the following parameters in tables 1.1, 1.2, 1.3 and 1.4:

[20 Marks]

Table 1.1 Ore-body characteristics

No	Parameter
1	Thickness **B**=15 m
2	Plunge υ=60 degrees
3	Coefficient of rock strength f= 6
5	Type of ore - strong & competent
6	Surrounding rock medium type - strong & competent

Table1.2 . Parameters of slice

No.	Geometry
1	Height of slice **h**=20
2	Length of slice **L**= Thickness of ore body
3	Width of slice, **w** = burden
4	Density of ore, τ=3.5 t/m^3
5	Area of extraction drive driven in the slice, **A**= 10.24 m^2

Table 1.3. Blasting parameters

No.	Description
1	Hole diameter **d**=75 mm
2	Linear charge **U**=3.96 kg/m
3	Charging Density ρ=1
4	Hole charging coefficient φ=0.85
5	Type of explosive = ANFO

Table 1.4. Economic indices

No.	Parameter
1	Recovery **R**=85 %
2	Dilution **D**= 5 %
3	Productivity of Drilling Machine $\mathbf{P_d}$=150 m/shift
4	Productivity of Charging Machine $\mathbf{P_c}$= 1100 kg/shift

Question 2

Using an idealized example of pit optimization based on Jeff Whistle and theoretical pit values of ore and waste, explain how optimum pit is determined.

[20 Marks]

Question 3

A small copper mine produces ore from two (2) working stopes. The ore from the first stope yields a profit of \$5.8/t and contains 0.35 % arsenic. The ore in the second stope yields a profit of \$6/t and contains 0.65 % arsenic. The smelter requires that the average arsenic content of ore received cannot exceed 0.50 % and the mine haulage system makes it impossible to handle more than 400 t/shift. Find the optimum tonnages that can be mined from each stope and the maximum profit realized.

[20 Marks]

Question 4

A haulage drift having a cross section area of 16.25 m^2 and length of 50 m is to be driven in the waste rock. Given the parametres in table 3.1, determine:

a) Number of blast holes required to be drilled per face advance **[4 Metres]**
b) Required face advance **[2 Metres]**
c) Tonnage of waste broken per shift **[2 Metres]**
d) Powder factor **[4 Metres]**
e) Number of blasts per month **[4 Metres]**
f) Total length of blast holes to be drilled for the entire drift **[4 Metres]**

Table 3.1

Length blast holes, **L**=2 m
Advance Coefficient, ψ= 0.9
Rock strength coefficient, **f**=10
Density of ore, ρ= 2.5 t/m^3

Question 5

With the help of simplified diagrams and equations explain several ways of estimating annual production of the mine and state some of the major challenges that may arise in trying to expand production capacity of an existing mine.

[20 Marks]

Question 6

Figure 6.1 shows extraction points (A,B,C,D,E, G,H and I with associated raw tonnages and grades), routing their ore to the tipping point Z. Extraction point J connects directly to the tip. All the ore received at the tip is finally routed to the metallurgical mill. Calculate reconciled tonnages and grades for all points if the reported tonnage and grade at the mill is 38089 tonnes and 1.6 % respectively.

[20 Marks]

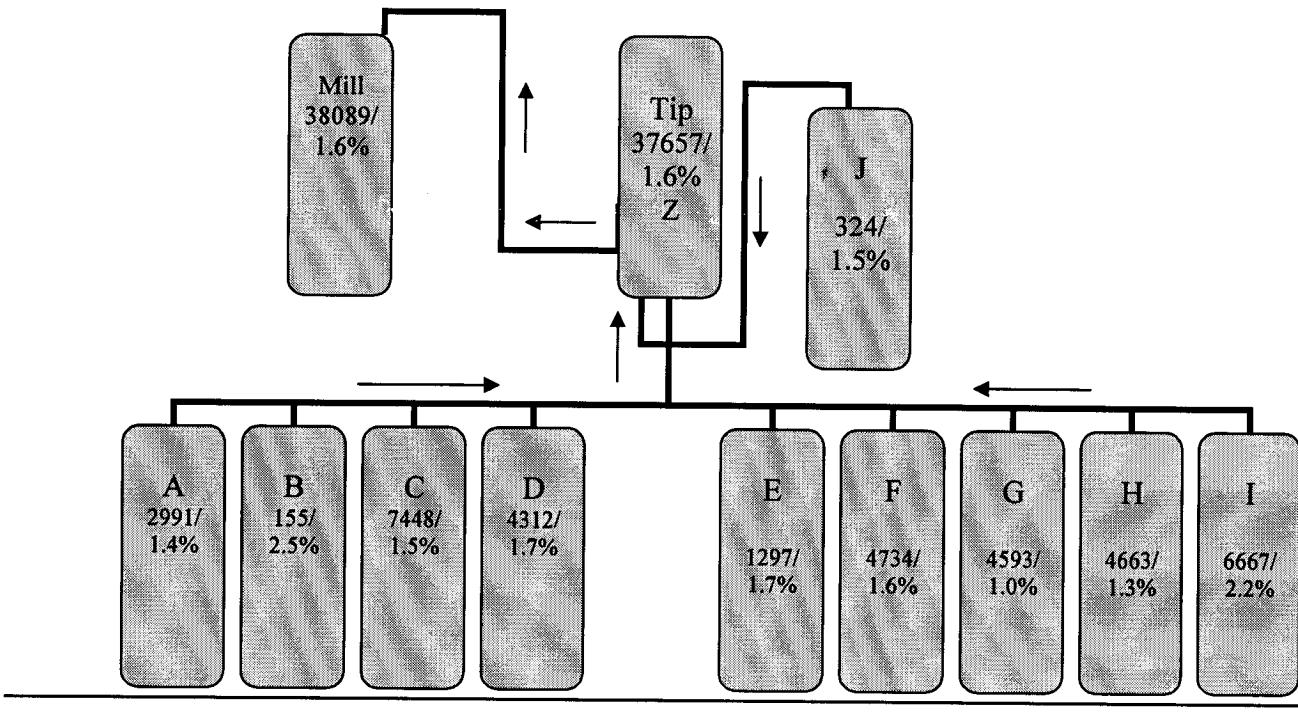

Figure 6.1. Ore- flow diagram

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 205 – INTRODUCTION TO METALLURGY II

TIME: ~~THREE~~ Two HOURS

ANSWER BOTH QUESTIONS.

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1. A, B, C, D and E are unknown mineral specimens provided to you. Determine the following physical properties on each of the minerals: Colour, Hardness, Streak, Lustre, Cleavage/Fracture, Reaction to acid, Reaction to a magnet and Touch. Name each of the minerals. (50 Marks)

2. X, Y and Z are rock samples. Using the following physical characteristics, determine the name of each rock: Colour, Minerals, Texture and any other feature. (30 Marks)

END OF EXAMINATION IN MM 205 II

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 205 – INTRODUCTION TO METALLURGY I

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS.

USE SEPARATE ANSWER BOOKS FOR EACH SECTION

SECTION I: INTRODUCTION TO GEOLOGY

1. (a) List the 8 groups of minerals and give one mineral example of each
   (b) On what basis is a mineral classified?
   (c) Distinguish covalent bonding from metallic bonding.
   (d) Define an isotope and list the isotopes of carbon.
   (e) Why would water not be regarded as a mineral? Would you say ice is a mineral, why?
   (f) Name and describe briefly 4 of the open forms you know.
   (g) Do the following:
      (i) Define a diad
      (ii) Define a centre of symmetry
      (iii) If the angle between two adjacent faces on a crystal was 125o, what would be the interfacial angle?

2. (a) If a rock is a mixture of one or more minerals, then what is an ore?
   (b) What would you expect the concentration of a metal in an ore and the metal-bearing mineral to be and why?
   (c) Give two examples of rocks tyeps for each of the following groups of rocks, igneous, sedimentary and metamorphic.
   (d) Describe briefly how glass is naturally produced.
   (e) Name and describe briefly the three main layers constituting earth.

SECTION II: INTRODUCTION TO METALLURGY AND MINERAL PROCESSING

3. (a) Define the following terms as applied to minerals engineering:-

(i) Terminal velocity
(ii) Projected area diameter
(iii) Equivalent spherical diameter
(iv) Reduction ratio
(v) Grindability (5 %)

(b) (i) What is meant by "cut-off grade" in mineral deposits evaluation? Give concentration estimates of iron (Fe), copper (Cu) and gold (Au) in their respective ores for them to be exploited profitably. (3 %)

(ii) How is energy required in size reduction related to particle size and hence surface area? Illustrate the relationship graphically. (3 %)

(ii) Mention any four (4) mineral concentration methods. With the aid of sketches, explain the principle of froth flotation. What are rougher, scavenger and cleaner cells in froth flotation circuits? Explain the role and objectives in each case. (5 %)

(iii) Distinguish between mineral resources and mineral reserves. Suggest some reasons why recycling of metals is important. Do you think that recycled metals will increasingly be important in the future? (4 %)

4. (a) What is roasting? Explain why concentrates are roasted prior to both leaching and smelting. (5 %)

(b) Write brief but clear notes on pyrometallurgical copper extraction, giving objectives of each stage and furnaces used, feed materials, main reactions, products and temperatures where possible under the following headings:-

(i) Smelting (5 %)
(ii) Converting (5 %)
(iii) Fire-refining (5 %)

5. (a) What is leaching? Mention any four (4) leaching methods and explain in detail how **any one** of these methods is carried out in terms of unit sizes, extractions times, yield or recovery, particle sizes, controls and costs involved. (6 %)

(b) (i) Compare between electro-winning and electro-refining. Give the anode and cathode reactions that occur during the electrowinning of copper. (4 %)

(ii) In a hydrometallurgical route of copper extraction, what is advance electrolyte and spent electrolyte? What are starting sheets and what are they made of? (4 %)

(c) Briefly explain the principles of solvent extraction in relation to the role of an extractant and the equilibrium reaction given below. Identify which reaction is the extraction or stripping one and cite which species are organic or aqueous; (6 %)

$$RH_n + Me^{n+} = RMe + nH^+$$

END OF EXAMINATION IN MM 205 I

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 332 – CHEMICAL THERMODYNAMICS II

TIME: THREE HOURS

ANSWER ANY (5) QUESTIONS. QUESTION ONE IS COMPULSORY

1

(a) Distinguish between a solution, a mixture and a compound. (3 %)

(b) The melting point of cobalt is 1480 °C. Calculate the Gibbs energy change for the transfer of one g-atom of cobalt from pure liquid to a 1 weight percent solution in liquid iron at 1500 °C. Assume that cobalt behaves ideally in iron at this temperature. The relative atomic weights are Fe = 55.85; Co = 58.9 (4 %)

(c) Solid Au-Cu alloys are regular in their thermodynamic behaviour. The integral enthalpy of mixing, ΔH^M, at 447 °C is given below as a function of composition.

X_{Cu}	0.2	0.3	0.4	0.5
ΔH^M, (J.mol^{-1})	- 2448	- 3556	- 4498	-5104

Calculate the integral molar free energy of mixing, ΔG^M of the above solution at X_{Cu} = 0.3 and X_{Cu} = 0.5. (4 %)

(d) The variation, with composition, of G^{xs} for liquid Au-Cu alloys at 1550 K is shown in the Table below;

X_{Cu}	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
G^{xs}, (J.mole^{-1})	-2170	-3850	-5050	-5770	-6010	-5770	-5050	-3850	-2170

Calculate: (9 %)

(i) $\overline{G}^{XS}_{Au}$ and $\overline{G}^{XS}_{Cu}$ at X_{Cu} = 0.3

(ii) ΔG^M at X_{Cu} = 0.3

2

Two hypothetical metals, A and B, whose melting points are 700 °C and 500 °C respectively, are completely miscible in the liquid state and are partially soluble in the solid state, the maximum solubilities being 5 % B and 25 % A by weight. The solubilities are 2 % and 5 % respectively, at 0 °C. The A-rich phase is α and the B-rich phase is β.

The two metals form a compound A_2B which melts at 750 °C and in which neither metal is soluble. The atomic weights of A and B are 30 and 50 respectively. Eutectics are formed at 22 % and 60 % by weight of B and at a temperature of 450 °C and 320 °C respectively.

(a) Draw a phase diagram on a graph paper and label the areas in the phase diagram with the relevant phases.

(b) Calculate the amounts of B in the conjugate phases at 200 °C for the equilibrium cooling of a 20 % B alloy.

(c) Sketch a Gibbs energy – composition diagram at 200 °C. Include all phases.

(20 %)

3

(a) At the moment of mixing, a solution contained 0.01 M $S_2O_8^{2-}$ and 0.02 M $Mo(CN)_8^{4-}$, which then reacted at 20 °C as follows:- (8 %)

$$S_2O_8^{2-} + 2\,Mo(CN)_8^{4-} = 2SO_4^{2-} + 2Mo(CN)_8^{3-}$$

The rate law is of the form

$$-\frac{dC_A}{dt} = K_2 C_A C_B$$ where A denotes $Mo(CN)_8^{4-}$ and B denotes $S_2O_8^{2-}$

(i) Calculate the value of K_2 if C_A = 0.015 moles / litre after 30 hours.

(ii) Calculate the initial rate.

Hint: You may use the integrated rate equation for a second-order reaction.

(b) The following data were obtained for the kinetics of reduction of FeO in slag by carbon in molten pig iron at a certain temperature: (12 %)

Concentration of FeO in slag, wt %	20.00	11.50	9.35	7.10	4.40
Time, min	0	1.0	1.5	2.0	3.0

(i) Using the Van't Hoff's differential method, calculate the order of the reaction with respect to FeO

(ii) Taking the order of reaction calculated in (i) above, calculate the rate constant and half-life for this process.

4

(a) Distinguish between a "Galvanic Cell" and an "Electrolytic Cell" For each; indicate the polarity of the electrodes and the nature of the electrode reactions. (3 %)

(b) The reaction of a cadmium-calomel cell is represented as

$$Cd + Hg_2Cl_2 = Cd^{++} + 2Cl^- + 2Hg,$$

where all the components are present in their standard states. The reversible e.m.f. (in V) of the above cell varies with temperature (in K) according to the following relation: (9 %)

$$E^\circ = 0.67 - 1.02 \times 10^{-4} (T - 298) - 2.4 \times 10^{-6} (T - 298)^2$$

Calculate the values of ΔG°, ΔS° and ΔH° for the above reaction at 40 °C.

The Faraday's constant, F = 96 487 C/g-equivalent
Universal gas constant, R = 8.314 J/k/mol

(c) The standard free energy change in the temperature range 298 to 1500 K for the reaction; (8 %)

$$Mn_{(s)} + H_2O_{(g)} = MnO_{(s)} + H_{2(g)} \text{ is } \Delta G^\circ = -138\,700 + 18.0\,T \text{ joules}$$

(i) The reaction $Mn + H_2O = MnO + H_2$ is set up in a Galvanic cell. Calculate the standard e.m.f. of the cell, the maximum work obtainable from this cell, and the heat transfer between the cell and its constant-temperature heat reservoir when it is operated reversibly.

(ii) Calculate the e.m.f. of the cell when the ratio of the pressures of H_2 and H_2O is 1000/1

5

(a) The following data have been obtained for Cr-Ti solutions at 1523 K.

X_{Cr}	0.09	0.19	0.27	0.37	0.47	0.67	0.78	0.89
a_{Cr}	0.302	0.532	0.660	0.778	0.820	0.863	0.863	0.906

Using the appropriate form of Gibbs- Duhem equation, calculate the activity of titanium in a Cr-Ti solution containing 60 atom % Ti (14 %)

(b) The excess partial molar free energy of zinc in liquid in liquid Cu-Zn alloys at 1027 °C can be expressed as

$$\overline{G}_{Zn}^{XS} \text{ (cal/mole)} = -5150\,(1 - X_{Zn})^2$$

Calculate the activity of copper at 1027 °C in an equiatomic solution. (6 %)

6

(a) During carbon dioxide arc welding, carbon and oxygen from the CO_2 enter into solution in iron at 1600 °C according to

$(CO_2) = [C]_{Fe,\,wt\%} + 2[O]_{Fe,\,wt\%}$; where $\Delta G^\circ = 43\,855 - 11.4T$ Cal

The final oxygen content of the weld is represented by

$$\log [\%\,O] = -\frac{6320}{T} + 2.734$$

Calculate the equilibrium carbon content of the weld if the partial pressure of CO2 is 1 atm. Assume the following interaction parameter values: (10 %)

$e_O^C = -0.13$; $e_C^O = -0.1$; $e_O^O = -0.2$; *and* $e_C^C = 0.22$

(b) The activity coefficient of Zn in liquid Cd-Zn alloys at 435 °C can be represented by

$$\log \gamma_{Zn} = 0.38X_{Cd}^2 - 0.13X_{Cd}^3$$

Calculate the corresponding expression for the composition dependence of γ_{Cd}, and hence calculate a_{Cd} in the $X_{Cd} = 0.5$ alloy at 435 °C. (10 %)

END OF EXAMINATION IN MM 332

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 412 – MINERAL PROCESSING II

TIME: THREE HOURS

ANSWER FIVE QUESTIONS. QUESTION 6 IS COMPULSORY

1.

(a) Gravity concentration methods have found wide application in the minerals industry. Give reasons to account for this.

(b) What do you understand by "concentration criterion" in gravity separation? State what use is made of this criterion in the separation of minerals by gravity methods?

(c) What is jigging? And what are its main applications?

(d) Discuss with neat sketches the operation of:

(i) Harz jig
(ii) Pinched sluice

2.

(a) Describe the dense medium separation (DMS) as used in the minerals industry.

(b) Show the stages (with a flowsheet) of DMS.

(c) What properties or qualities should a good dense medium have in dense medium separation process? And what advantages does DMS have over other gravity processes?

(d) Name some of the substances used in DMS and give their advantages and disadvantages.

(e) Describe with neat sketches the operation of:

(i) Vorsyl separator
(ii) Larcodems separator
(iii) Tri-Flo separator

3.

(a) Outline in fair detail the principles of flotation.

(b) Describe the role of each of the following reagents as used in flotation:

(i) Collector
(ii) Frother
(iii) Regulator

Give examples of each of the above reagents.

(c) Outline the various factors that may affect the steady control of flotation process.

(d) What do you understand by:

(i) Rougher cells
(ii) Scavenger cells
(iii) Cleaner cells?

4.

(a) What do you understand by flotation schemes? Give some examples with appropriate flowsheets.

(b) Briefly describe the flotation processes for:

(i) Lead-zinc ores, and
(ii) Copper sulphide ores

(c) Describe the column flotation cell

5.

(a) Describe briefly with sketches where possible the three main processes/methods used in dewatering or solid-liquid separation.

(b) Give a brief discussion on the separation of minerals by electrostatic separation and high-tension separation. Briefly describe the basic principles involved and the main types of equipment in use.

(c) Briefly describe the construction of tailings dams by the spraying method and by cycloning. Illustrate with sketches.

6.

(a) The feed to a flotation plant assays 1.65% copper and 0.12% cobalt. The concentrate produced in the rougher cells assays 31.5% copper, 0.81% cobalt, and tailings assay: 0.26% copper and 0.09% cobalt.

Calculate:

(i) The average recoveries of copper and cobalt to the rougher concentrate
(ii) The ratio of concentration
(iii) The enrichment ratio, and
(iv) Draw the appropriate flowsheet.

Hint:

$F = C + T$

$Ff = Cc + Tt$ where F = Weight of feed
C = Weight of concentrate
T = Weight of tailings
f, c, t are the corresponding assays respectively

(b) If an ore having a density, $\rho_s = 5.5$ kg/m^3 is to be floated at the rate of 6000 t/day, with pulp density, $\rho_p = 25\%$ solids and flotation time, $t_f = 20$ minutes.

(i) Find the number of chambers required for mechanical type machines, working capacity is 0.7 m^3.

Hint: $N = \frac{V_a t}{V_b K}$ where;

N = no. of flotation cells
V_a = quantity of pulp entering (m^3/min)
V_b = chamber capacity (m^3)
K = constant, 0.7
t = flotation time (min)
R = liquid-solid ratio

(ii) Attempt to draw the chambers (first 3 cells).

END OF EXAMINATION IN MM 412

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 442 – HYDROMETALLURGY

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS. THE CREDIT FOR A FULL ANSWER IS SHOWN IN BRACKETS BESIDE EACH QUESTION

1

(a)Starting from first principles and with the aid of any relevant assumptions, explain how you would establish whether a leaching reaction is chemically controlled or not. (7%)

(b)Outline how large amounts of dissolved iron can be removed from hydrometallurgical process solutions. (7%

(c)In a continuous agitation leaching and counter current decantation (CCD) operation, 3.75 tonnes of solute-free leachant is used for every 1.5 tonnes of an oxide concentrate. The concentrate contains 10% of leachable values, 10% moisture, and the remainder is insoluble material. All leachable values dissolve in the leaching vessel before the pulp is introduced into the first thickener of a 3 stage CCD washing operation. For every 1.5 tonnes concentrate leached, 5 tonnes of pure wash water is added in the last thickener which yields a disposable sludge, while 2 tonnes of pure wash water is added to the middle thickener.

(i) Draw a clearly labelled diagram which would best represent the operation as described above. (2%)

(ii) What is the amount of pregnant solution produced for every 1.5 tonnes of concentrate leached, assuming an underflow sludge with 25%, 40%, and 50% solids in the first, second, and last thickener, respectively? (3%)

(iii)With a further assumption that the repulping efficiency is 95%, 90%, and 85% in the first, second and last thickener, respectively, calculate the percentage of dissolved values recovered into the pregnant solution. (6%)

2(a)For (i) chelating and (ii) anion exchange eextractants, explain the extraction and stripping mechanisms. (7%)

(b)How is an extraction McCabe-Thiele diagram generated for a solvent extraction plant and how is such a diagram used? (9%)

(c)A leach solution with 0.975 g/l Cu^{2+} is used to study Multiple batch extraction with LIX 894 dissolved in Escaid as the organic phase. At each stage of extraction, 30 cm^3 of fresh organic is equilibrated with the aqueous phase. If in the first stage of extraction 100 cm^3 of the leach solution is used yielding at equilibrium an extract and raffinate with 1.98 and 0.381 g/l copper respectively, determine the least number of equilibrium stages required to yield a final raffinate with not more than 0.013 g/l copper. Assume a constant distribution coefficient of copper at each stage and that the organic and aqueous phases are immiscible. (9%)

3(a)It is desired to recover copper by cementation from spent electrolyte that is due to be discarded because of a high build-up of impurities. Iron powder is added to achieve this. If the final Fe^{2+} concentration in the de-copperized spent electrolyte is 50 g/l, how much copper (in g/l) is left in the electrolyte after cementation? Take the electrolyte temperature as 45 °C and assume ionic activities are equal to molar concentrations. (10%)

Atomic weight of Fe = 55.8; Cu=63.5
Universal gas constant, R = 8.314 J/deg/mol.

$Cu^{2+} + 2\_ = Cu \quad E° = 0.337$ V
$Fe^{2+} + 2\_ = Fe \quad E° = -0.440$ V

(b)The cementation reaction in the above qustion requires much more iron than the stoichiometric amount. Why? (7%)

(c)In the neutral leaching of zinc calcine, a 0.2 molar Zn^{2+} solution is approaching equilibrium with $Zn(OH)_2$ and $Fe(OH)_3$. Calculate the equilibrium Fe^{3+} concentration (in g/l) and pH of the solution when for the reactions, $Zn(OH)_2 = Zn^{2+} + 2OH^-$ and $Fe(OH)_3 = Fe^{3+} + 3OH^-$ the equilibrium constants are $4.5 * 10^{-17}$ and $6 * 10^{-38}$, respectively. Assume that ionic activities are equal to molar concentrations. (Relative atomic weight of Fe = 55.8) (8%)

4(a)In copper electrometallurgy: (8%)

(i)What is meant by "periodic current reversal" (PCR) and what advantages does it offer?

(ii)Can PCR be used for electrowinning? Explain.

(b)Calculate the energy (in kWh) required to electrodeposit divalent copper on cathodes at a cell voltage of 2.5 V and a current efficiency of 85%. (Relative atomic weight of Cu = 63.5; F = 96500 C/mol)) (7%)

(c)Calculate the total cathode area required to electrowin 50% of the Mn^{2+} as manganese metal from a feed stream with a flow rate of one litre/second and a manganese concentration of 30 g/l if the applied current density is 6 A/dm^2 at a current efficiency of 65%. (F = 96500 C/gmol; Mn relative atomic weight = 54.94) (10%)

END OF EXAMINATION IN MM 442

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 422 – PHYSICAL METALLURGY II

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS.

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1. Discuss the validity of the following statements, in each case explaining your reasoning:

   (a) Martensite is a desirable constituent in tool steels.

   (b) In the presence of an aggressive environment, a material may actually fail below K_{IC}.

   (c) Fine-grained materials have the same strength as those that are coarse-grained.

   (d) Mild steel may fracture in a brittle manner at very low temperatures.

2. (a) Describe, with the aid of an appropriate sketch, the mechanisms of strain hardening.

   (b) During strain hardening, why is it essential to anneal a material?

   (c) Explain the process of polygonization during the recovery stage of annealing.

   (d) For each of the materials given below, list those strengthening mechanisms that measurably contribute to the strength of the material in its stated form.

      (i) Pure aluminium sheet, rolled from 0.6 cm to 0.3 cm in thickness.

      (ii) 70%Cu-30%Zn polycrystal.

      (iii) 4.5%Cu-95.5%Al, water-quenched from single phase region and held for 1 hour at 204°C.

      (iv) A very large steel component requiring a hard wear-resistant surface.

3. (a) Describe how Time-Temperature-Transformation (TTT) curves for steel can be constructed.

(b) What are the M_s and M_f curves on the TTT curves?

(c) During quenching of a fully austenitic steel, what microstructure would be expected if the M_s curve is crossed but the M_f curve is not?

(d) What microstructure result from each of the following treatments, taken independently, of a previously annealed 0.80 wt.% C steel (The Fe-Fe_3C phase diagram is attached).

(i) heat to 730°C, water quench

(ii) heat to 815°C, air cool

(iii) heat to 150°C, water quench

(iv) heat to 760°C, furnace cool

4. (a) What is the fatigue limit and in which materials is it likely to be noticeable?

(b) According to the Griffith criterion, why will a crack propagate in a structure even under the apparent absence of any external stress?

(c) What is the main limitation of the Griffith criterion and how has it been accounted for?

(d) Using Griffith's equation for plane stress, determine the critical crack length for iron

$$\sigma_f = 900 \times 10^6 \text{ N/m}^2$$

$$\gamma_s = 1.2 \text{ J/m}^2$$

$$E = 20.5 \times 10^{10} \text{ N/m}^2$$

(e) What is the critical crack length in iron according to the Orowan equation if $\gamma_p \approx 1000 \text{ J/m}^2$

5. (a) With the aid of appropriate sketches, outline how you would use x-ray diffraction to show the existence of residual stress in a material.

(b) What is constructive interference and when does it occur during diffraction?

(c) At low temperatures, Cu_3Au is cubic with one formula unit per unit cell. If the Au atom is placed at the origin, then the Cu atoms will be situated at 0½½, ½0½ and ½½0.

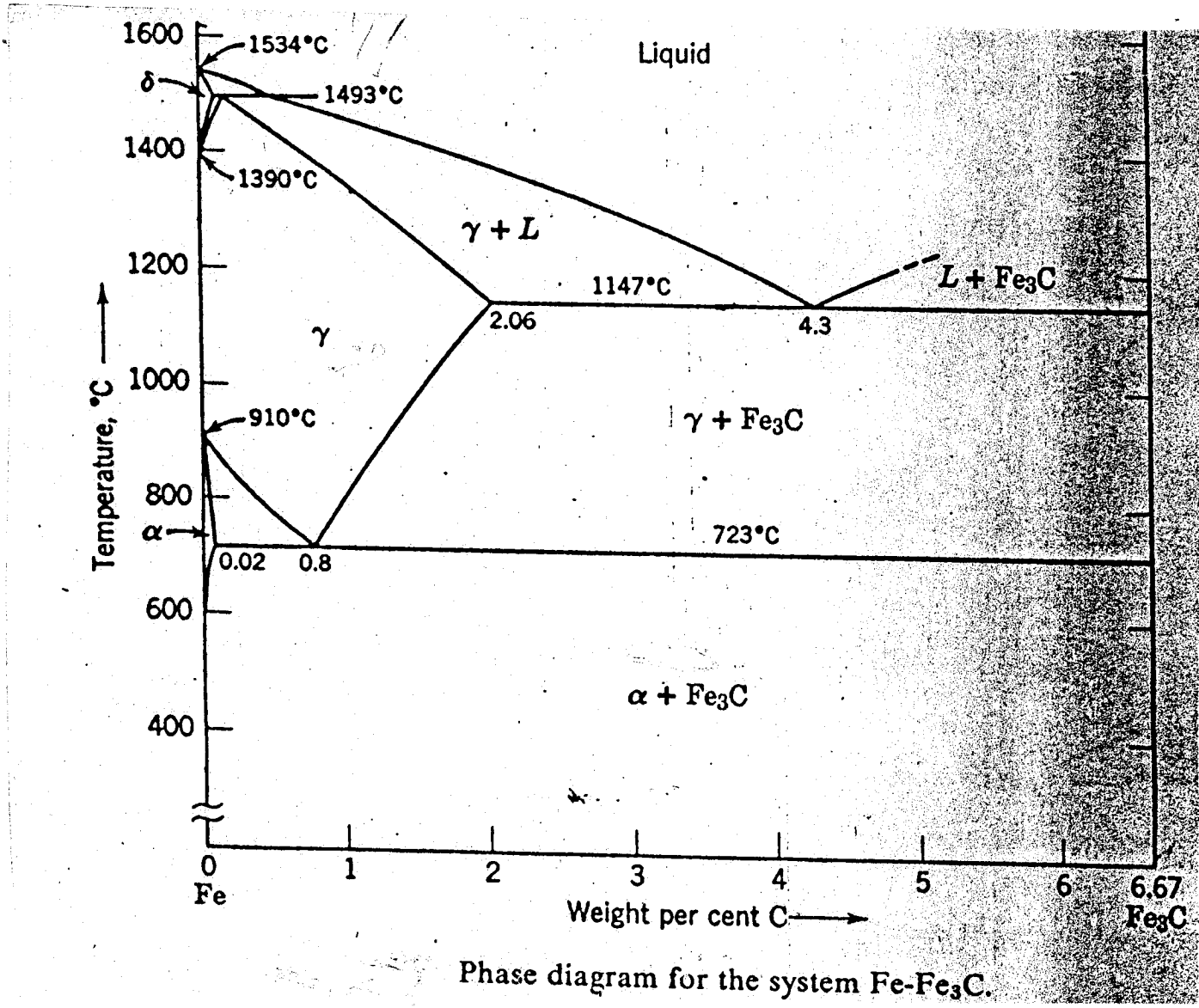
(i) Write down the expression for the structure factor F_{hkl}.

(ii) What will be the form of the structure factor when h, k and l are all even or all odd?

(iii) What will be the form of the structure factor when h, k and l are mixed?

$$F_{hkl} = \sum_{n=1}^{N} f_n \exp 2\pi i (hx_n + ky_n + lz_n)$$

END OF EXAMINATION IN MM 422



Phase diagram for the system Fe-Fe_3C.

THE UNIVERSITY OF ZAMBIA

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UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 452 – PROCESS CONTROL AND INSTRUMENTATION

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS.

WHERE APPLICABLE, ALL CALCULATIONS ARE TO BE PERFORMED CORRECT TO THREE DECIMAL PLACES.

ADDITIONAL INFORMATION IS PROVIDED WITH THE QUESTION PAPER.

---

1. (a) What is meant by feedback control?

(4 marks)

(b) A minibus driver uses the difference between the actual speed and the desired speed of the minibus to generate a controlled adjustment of the speed. Draw a block diagram to illustrate this feedback system. Indicate the variables into and out of each block

(5 marks)

(c) The dynamics of a tank without any control are given as follows:

$$\rho A \frac{dh}{dt} = x(t) = \Delta w(t)$$

Assume that $h(0) = h_0$.
Derive the expression for h(t) for a step input magnitude Δw starting at $t = t_d$.
Give the output in dimensionless form and determine its value at $t/t_d = 3$.

(6 marks)

(d) Linearise the following equation and convert to perturbation variables:

$$\frac{dy}{dt} + \alpha y^2 + \lambda \ln y = x(t)$$ α, λ are constants

(5 marks)

2. (a) An isothermal, first-order, liquid-phase, irreversible reaction is conducted in a constant-volume batch reactor thus

$$B \xrightarrow{k} C$$

The initial concentration of reactant B at the beginning of the batch is C_{B0}. The specific rate k decreases with time because of catalyst degradation as $k = k_0 e^{-\alpha t}$. Solve for $C_B(t)$.Show that in the limit as $\alpha \rightarrow 0$, $C_B(t) = C_{B0} e^{-k_0 t}$ and that in the limit as $\alpha \rightarrow \infty$, $C_B(t) = C_{B0}$. What is the physical significance of each of these limits?

(6 marks)

(b) A first order system is written as follows:

$$u(t-2) = \frac{3}{2}u(t-8) - \frac{1}{2}y - 2\frac{dy}{dt} \qquad \text{at } t = 0,\ y = 2.$$

Using Laplace transforms, find y(t). What is the value of y when t = 3?

(14 marks)

3. (a) A dynamic equation is of the following form:

$$t\frac{dy}{dt} - y = 3t^3$$

Given that y = -1 when t = 1, solve for the output y(t).

(5 marks)

(b) A cylindrical tank having a cross-sectional area of $0.2m^2$ is operating at steady state with an inlet flow rate of $6x10^{-2}$ m^3/min. The flow-head characteristics are given by

$$F_o = 0.12h + 0.036$$

where F_o is the outlet flow rate in m^3/min and h is the liquid level in metres.

(i) Determine the transfer function relating the inflow F_i^* and liquid level h^*.

(ii) If the inflow increases by $6x10^{-3}$ m^3/min according to a step change, calculate the liquid level 3 minutes after the change has occurred. What is the ultimate liquid level h(3)?

(15 marks)

4. (a) Briefly discuss the importance of measurements in feedback control.

(3 marks)

(b) The response of an underdamped second-order system to a unit step change may be shown to be

$$y^*(t) = 1 - \frac{1}{\sqrt{1-\zeta^2}} e^{-\zeta t/\tau} \sin\left(\frac{\sqrt{1-\zeta^2}}{\tau} t + \phi\right)$$

where $\phi = \tan^{-1} \frac{\sqrt{1-\zeta^2}}{\zeta}$.

(i)Derive expressions for the overshoot, decay ratio and the rise time.

(10 marks)

(ii)An underdamped second-order system has a time constant τ of 0.5 min and a damping ratio ζ of 0.5. What is the response $y^*(t)$ to unit step change in input? **Calculate** the overshoot, the rise time and period.

5. A process has an openloop transfer function relating controlled and manipulated variables that is a first-order lag with time constant τ_p with a steady state gain K_p. There is additional first-order lag with time constant τ_s and steady state gain $K_s = 1$ in the measurement (or sensing) of the controlled variable. A proportional only feedback controller is used.

(a) Draw a block diagram of the control system with $y^*(t)$ as output and y^*_{set} as the setpoint.

(5 marks)

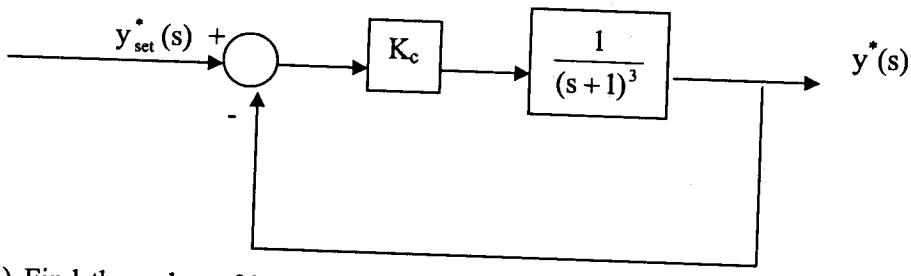
(b) Derive an expression relating the controller gain K_c to the parameters τ_p, τ_s and K_p such that the closedloop system damping ratio ζ is 0.707. Keeping ζ at this constant value, what happens to K_c as τ_s gets very small or very large? What is the value of τ_s that provides the minimum value of K_c in terms of τ_p?

(12 marks)

(c) Obtain an expression for the offset for a unit step change in set point.

(3 marks)

6. A control system is shown in the figure below: -



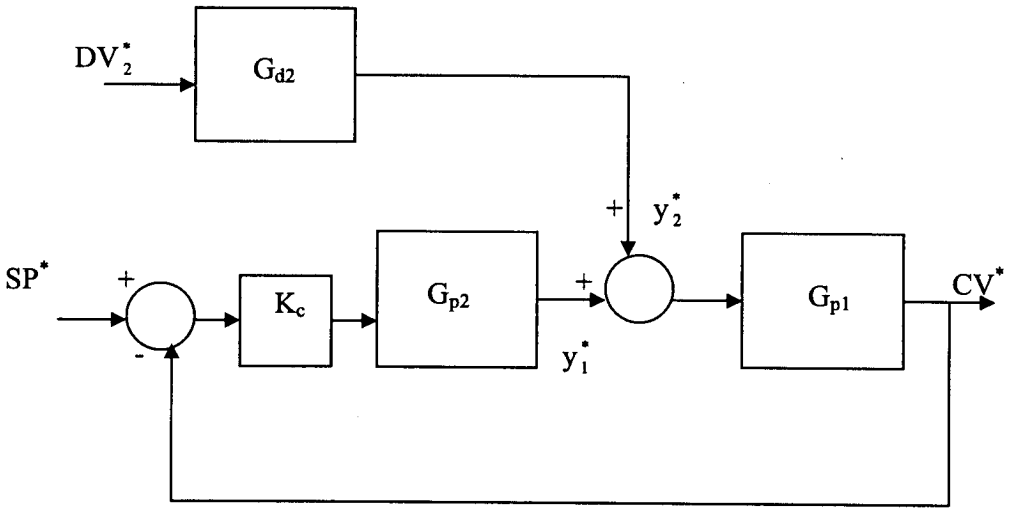
(a) Find the value of K_c for which the system is on the verge of instability. Determine the other pole.

(12 marks)

(b) The controller is replaced by a PD controller for which the transfer function is $K_c(1 + T_d s)$. If $K_c = 10$, determine the range of T_d for which the system is stable.

(8 marks)

7. Here is a control system:



where $G_{p1}(s) = \dfrac{1}{s+1}$ and $G_{p2}(s) = G_{d2}(s) = \dfrac{1}{0.5s+1}$

Any valves, transducers, etc, have unity transfer functions.

(a) Derive the expression for the transfer function between CV^* and DV_2^* assuming that SP^* is zero.

(b) Determine the value of the controller gain K_c that would give a damping ratio ζ of 0.707 for a unit step disturbance in DV_2^*. What is the offset?

(c) Calculate the overshoot corresponding to part (b).

Remember: Overshoot = $e^{-\pi\zeta/\sqrt{1-\zeta^2}}$.

END OF EXAMINATION IN MM 452

Table of Laplace Transforms

f(t)	f(s)	f(t)	f(s)
u(t)	$\frac{1}{s}$	tu(t)	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$	$e^{-at}u(t)$	$\frac{1}{s+a}$
$t^n e^{-at}u(t)$	$\frac{n!}{(s+a)^{n+1}}$	sin kt u(t)	$\frac{k}{s^2+k^2}$
cos kt u(t)	$\frac{s}{s^2+k^2}$		

Inversion by partial fractions

METHOD 1

Suppose $L\{x(t)\} = x(s) = \frac{F(s)}{(s+k_1+jk_2)(s+k_1-jk_2)}$

where F(s) is some real function of s.

Let the function x(s) after partial fraction expansion become

$$x(s) = F_1(s) + \left(\frac{a_1+jb_1}{s+k_1+jk_2} + \frac{a_1-jb_1}{s+k_1-jk_2}\right)$$

where a_1 and b_1 are constants evaluated in the partial fraction expansion and $F_1(s)$ is a series of fractions arising from F(s).

Then the inverse transform arising from the complex root reduces to

$$2e^{-k_1 t}(a_1 \cos k_2 t + b_1 \sin k_2 t)$$

METHOD 2

Suppose x(s) after partial fraction expansion becomes

$$x(s) = F_1(s) + \frac{Bs+C}{(s+a)^2+k^2}$$

Then $$x(s) = F_1(s) + B\frac{s+a}{(s+a)^2+k^2} + \left(\frac{C-aB}{k}\right)\frac{k}{(s+a)^2+k^2}$$

The inverse transform arising from the above becomes

$$x(t) = F_1(t) + Be^{-at}\cos kt + \left(\frac{C-aB}{k}\right)e^{-at}\sin kt$$

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 542 – FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS. THE CREDIT FOR A FULL ANSWER IS SHOWN IN BRACKETS BESIDE EACH QUESTION

1(a)With respect to coal, what are "proximate" analyses? Explain how such analyses are determined. (5%)

(b)Indicate qualitatively how the proximate analyses and calorific value vary in the coalification series. (5%)

(c)In what ways is the storage of coal challenging? How are such challenges addressed? (5%)

(d)Why is coke, but not coal, an important fuel for blast furnaces? Explain the mechanism involved in the transformation of coal into coke. (5%)

2(a)Is electrical energy a renewable resource? Explain your answer. (4%)

(b)Rank the following six fuels in ascending order from the leanest to the richest: (4%)

producer gas (air and steam injected), natural gas, Blue water gas, blast furnace gas, carburetted water gas, and producer gas (air injected).

(c)With emphasis on the equipment used and chemical reactions, give an outline of the manufacture of carburetted water gas. (5%)

(d)One kilogram of a liquid fuel analyzing 85 weight percent carbon and the balance being hydrogen is burnt with air (79% N_2 and 21% O_2 by volume) . If combustion air used is 10% in excess of stoichiometric requirements, calculate the wet off gas composition. (Relative atomic weights: C = 12.0; H = 1.0. One kilomole of any gas occupies 22.41 Nm^3) (7%)

3(a) Answer the following questions about liquid fuels: (6%)

(i)What is meant by the "flash point"?

(ii)Distinguish between "gross" and "net" calorific values.

(iii)In what unit is Redwood viscosity measured? How is this viscosity determined?

(b)In qualitative terms, contrast kerosine and heavy fuel oil with respect to their composition, physical properties, and calorific value. (5%)

(c) In what unit is hot strength of refractory bricks measured and how is the determination of such strength done? (5%)

(d) How is the resistance of a brick to attack by a given slag studied under laboratory conditions? (4%)

4(a)Rank the following six refractory bricks according to decreasing Al_2O_3 content and then explain in general qualitative terns how the properties of the bricks vary in your indicated series: (62%)

(i) sillimanite, (ii) siliceous firebrick, (iii) mullite, (iv) aluminous firebrick, (v) andalusite, and (vi) firebrick.

(b) Outline the transformations that would occur in naturally occurring silica as its temperature is increased from room temperature to just below its melting point, cooling it back to room temperature , and then finally re-heating it to 1300 °C. (6%)

(c) How do the transformations cited above assist in understanding the care needed in the manufacture and use of silica bricks? (4%)

(d) State, giving reasons, some prominent uses of the silica brick. (4%)

5(a) What unique properties are possessed by each of the following refractory materials: (i) Chromite, (ii) Graphite? (4%)

(b) How are the above named materials with their unique properties used in the metallurgical industry? (5%)

(c) What precautions are to be taken in the use of carbon bricks?: Why? (5%)

(d) Outline the process by which stabilized dolomite bricks are manufactured and state the major phases present in such bricks. (6%)

END OF EXAMINATION IN MM 542

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 552 – PROCESS DESIGN

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS. ADDITIONAL DATA IS PROVIDED WITH THE QUESTION PAPER

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1. (a) Briefly discuss the significance of degrees of freedom in process design. (3 marks)

(b) Deduce the number of design variables for a stream divider that separates one stream into two streams of the same composition. How may the design variables be utilised?

(4 marks)

(c) Indicate the order of solution of the following set of equations:

$$f_1(x_1, x_2, x_3) = 0$$
$$f_2(x_1, x_3) = 0$$
$$f_3(x_4) = 0$$
$$f_4(x_3, x_4) = 0$$

(4 marks)

(d) A Cu – 5% Sn – 10% Si – 5% Zn alloy is melted. If there is a 10% loss of Zn from the charge during melting, and the following alloys are available, how many kg of each alloy would you charge to make 100 kg of alloy?

	%Cu	%Sn	%Zn	%Si
Alloy A	70.0		30.0	
Alloy B	82.5	16.0		1.5
Alloy C	68.0	2.0		30.0
Pure Cu	100.0			

(9 marks)

2. (a) In considering the anatomy of a manufacturing plant, two stages comprise product separation and product purification. Briefly comment on these stages. (5 marks)

(b) The flow diagram below represents part of a sulphuric acid plant.

The gases from the converter go to an absorption column in which 95 wt. % of the SO_3 is absorbed into 70 wt. % H_2SO_4 to generate 98 wt. % H_2SO_4. Part of the concentrated H_2SO_4 is diluted with H_2O to generate 70 wt. % H_2SO_4 which is recycled to the column. The composition of the absorber feed gas is as follows:

(c) Derive the formula giving the relationship between the present worth of an ordinary annuity, P, the interest rate, i, and the annual payments, R, for n discrete periods. Using this relationship, solve the following problem relating to the cash flows to an oil company:

The estimated cash flows (in **billions of Kwacha**) to the company are as follows:

Year			
0	**1 to 4**	**5**	**6 to 20**
0	2	-26	4

Calculate the net present worth at an interest rate of 10%.

(12 marks)

7. (a) Two of the important factors in the selection of a plant location are marketing area and utilities. Comment on these factors, giving some examples.

(8 marks)

(b) In the filtration of a sludge, the initial period is effected at a constant rate with the feed pump at full capacity, until the pressure difference reaches 400 kN/m^2. The pressure is then maintained at this value for the remainder of the filtration. The constant rate operation requires 900s and one-third of the total filtrate is obtained during this period.

Neglecting the resistance of the filter medium; determine

(i) the total filtration time and the filtration cycle,
(ii) the total cycle time for a maximum daily capacity.

Assume that the time for removing the cake and reassembling the press is 1200s. The cake is not washed.

Please note: $P = (K_1V + K_2)q$

where $K_1 = \dfrac{s\rho\mu\alpha_{av}}{(1-ms)A^2}$ and $K_2 = \dfrac{R_m\mu}{A}$

END OF EXAMINATION IN MM 552

5. (a) The purchased and installation costs of some pieces of equipment are given as a function of weight rather than capacity. An example of this is the installed costs of large tanks. The 1998 cost for an installed aluminium tank weighing 90,800 kg was K0.7 billion. For a size range of 90,800 kg to 454,000 kg, the installed cost-weight exponent for aluminium tanks is 0.93. If an aluminium tank weighing 317,800 kg is required, what is the present (**2007**) fixed capital investment required?

Index in 1998 = 106
2000 = 108, 100 (change of basis)
2004 = 110

Assume that the average increase in costs is 2.5 per cent per year.

(6 marks)

(b) A manufacturing company has found two different machines that will expand its current production. The net cash flows for each machine are as follows:

Year	Cash flow in millions of Kwacha	
	Machine 1	*Machine 2*
1	500	200
2	500	200
3	100	300
4	0	800

The initial investment in each case is 1000 million Kwacha.

(i) How many years would it take to pay back the initial investment for machines 1 and 2? For intermediate values, use a linear relationship between years. Which machine would you choose?

(ii) Calculate the net present worth for each machine at an interest rate of 5%. Which machine would you choose?

(iii) Show that the discounted-cash-flow rate of return for machine 1 is 6% and that of machine 2 is 17.2%. Which machine would you choose?

6. (a) Depreciation may be interpreted as a tax allowance and as a cost of operation. Comment on these contexts.

(4 marks)

(b) A piece of equipment originally costing K200 million was put into use 12 years ago. At the time the equipment was put into use, the service life was estimated to be 20 years and the salvage value was to be zero. On this basis, a straight line depreciation fund was set up. The equipment can now be sold at K50 million and a more advanced model can be installed for K275 million. Assuming the depreciation fund is available for use, how much new capital must be supplied to make the purchase?

(4 marks)

3. (a) Distinguish between the heat balance and the total energy balance.

(5 marks)

(b) A gas mixture is burned with 10% excess air that is preheated to 1000^0C (1530^0F). The composition of the gas mixture is as follows:

Component	%	ΔH_c^0 x 10^{-3} kJ/kmol
CO	28	-282.989
CO_2	4	
H_2	4	-241.826
CH_4	2	-890.346
H_2O(g)	1	
N_2	61	

The exit gas mixture leaves at 1500^0C(2730^0F). The heat of combustion of H_2 is based upon producing H_2O(g). The heats of combustion data are given at the standard atmosphere pressure and 25^0C. Calculate the kmols in the exit gas and the heat transferred for *100 kmols of the inlet gas mixture.*

1 calorie = 4.18 Joules

Atomic weights: C,12; O,16; H,1; N,14.

(15 marks)

4. (a) It is desired to warm an oil of specific heat 2.0 kJ/(kg)(K) from 300 to 325 K by passing it through a tubular heat exchanger with metal tubes of inner diameter 10 mm. Water of specific heat 4.17 kJ/(kg)(K) flows along the outside of the tubes with inlet temperature 372 and outlet temperature 361 K. The overall heat transfer coefficient from the water to oil, based on the inside area of the tubes, may be assumed constant at 230 W/(m^2)(K) and 75 g/s of oil is passed through each tube. The oil is to make two passes through the exchanger. The water makes one pass along the outside of the tubes.

Calculate

(i) the length of the tubes required,

(ii) the water flow rate in **kg/h**.

(12 marks)

(b) A counterflow heat exchanger of heat transfer area A = 14.0 m^2 is to cool oil [c_{Ph} = 2000 J/kg.^{0}C] with water [c_{Pc} = 4170 J/kg.^{0}C]. The oil enters at 100^0C and the flow rate is 2 kg/s while the water enters at 20^0C with a flow rate of 0.48 kg/s. The overall heat transfer coefficient is 400 W/(m^2)(^{0}C). Calculate the exit temperature of the water and the heat load.

(8 marks)

SO_2 = 0.65 mole %
SO_3 = 7.52 mole %
O_2 = 2.02 mole %
N_2 = 89.81 mole %

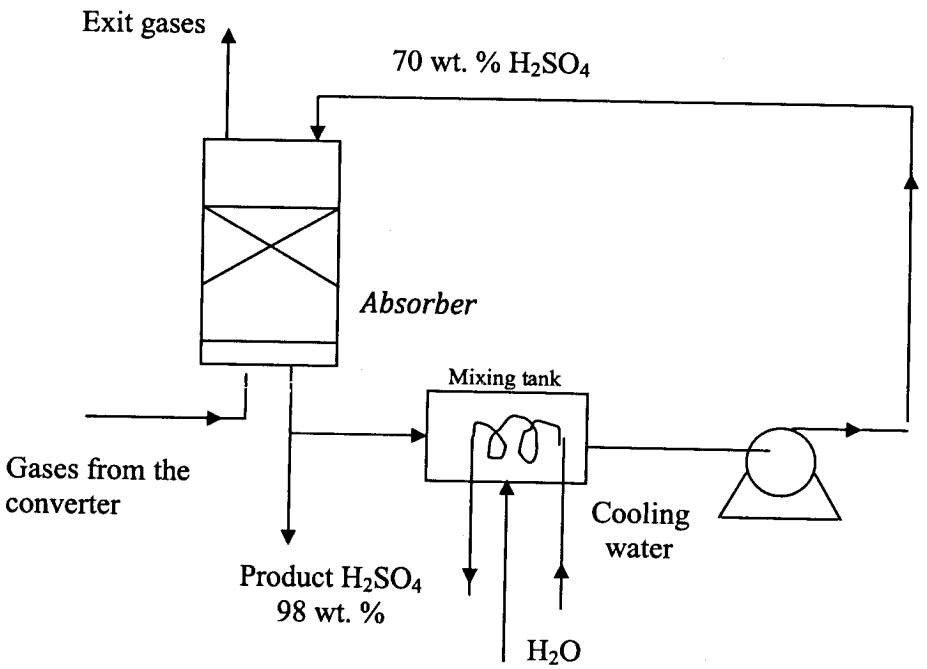
The absorption reaction is as follows:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Suppose the flow rate of the 70 wt % H_2SO_4 to the absorber is **20 kg/min,** calculate

(i) the rate of production of 98 wt % H_2SO_4 in **kg per min,**

(ii) the amount of water to be added to part of the 98 wt % H_2SO_4 to redilute it to 70 wt % H_2SO_4.



Atomic masses: H, 1; O, 16; N, 14; S, 32.

[**Hint**: As an initial basis, use **100 kmoles** of Feed gas from the converter]

(15 marks)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – FEBRUARY 2008

MM 562 – FOUNDRY

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS

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1. In many iron and steel foundries, there is a great reliance on the use of scrap metal resources to supplement input or charge materials to furnaces.

   (a) Explain the possible problems associated with the use of scrap metal

   (b) Give recommendations on the type quality control tests to be applied in the production of manhole covers in a steel foundry.

2. (a) Prior to casting at the ladle stage in a scrap processing foundry, the bubbling (or boiling) of melt may be an indication of undesirable reactions taking place. Give some suggestions as to what this may be and show the reactions. How is the final product affected if the necessary precautions are not taken?

   (b) Explain how the casting modulus of the various parts in a system is related to the concept of directional solidification.

3. (a) What differences, if any, would you expect in the properties of castings made by permanent mould versus sand casting methods?

   (b) What is the function of a core in a mould and what materials are cores made from?

   (c) Why are drafts necessary in mould design?

   (d) Why are allowances provided for, in making patterns? What do they depend on?

4. Write explanatory notes on the following factors that influence the final metallographic structure of a casting

(a) Superheat and final casting temperature
(b) Thermal properties of the alloy and mould
(c) Conditions for heterogeneous nucleation

What are the important features in the casting's sub-structure?

5. In selecting the best alloy requirements for a given task, it was desired that the mechanical specifications be 150 N/mm^2 ultimate tensile strength, 107 N/mm^2 yield strength and 7% elongation.

From the casting perspective it was noted that the alloy needed to be that would flow and fill the mould easily and not solidify too quickly as rapid solidification can produce cracks (hot tearing) in the casting.

From the given table of three alloy options, which one would best serve the above requirements based on strength, ductility, corrosion resistance, and castability requirements? Give your full reasons.

Alloy	Requirement	Alloy A	Alloy B	Alloy C
Performance				
Ultimate Tensile Strength N/mm^2)	150	270	163	171
Tensile Yield Strength (N/mm^2)	107	257	129	77
Ductility (% Elongation)	7	12	7	13
Corrosion Resistance (1= Excellent, 5 = Poor)	2	4	2	1
Castability				
Fluidity (1= Excellent, 5 = Poor)	2	2	1	5
Hot Tear Resistance (1= Excellent, 5 = Poor)	2	3	1	4

END OF EXAMINATION IN MM 562