

# National Exams May 2003

## 98-MMP-B5, Mill Design & Operations

3 hours duration

### NOTES:

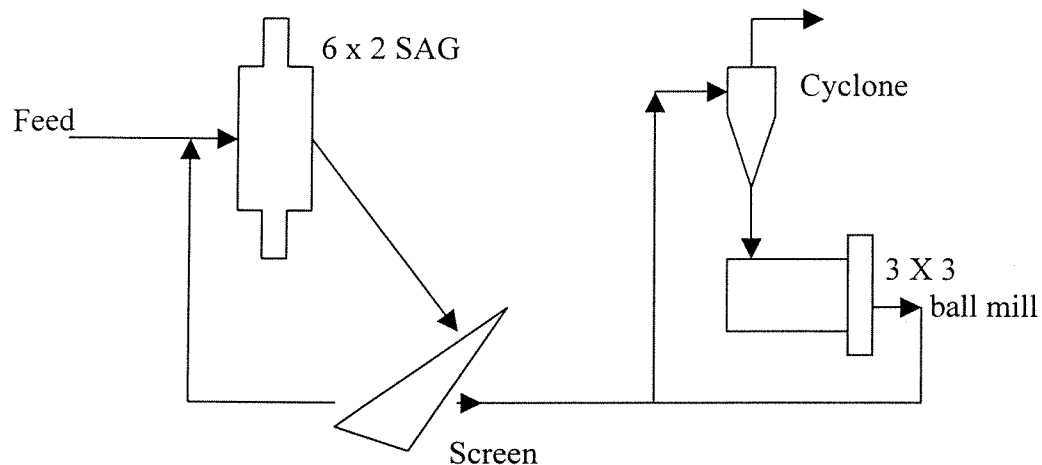
- 1, If doubt exists as to the interpretation of any question, the candidate is urged to submit with answer paper, a clear statement of any assumptions made.
- 2, Any non-communicating calculator is permitted. This is an open book exam.
- 3, Any five questions constitute a complete paper.
- 4, All questions are of equal value.

### Marking Scheme

- 1, (a) 5 marks, (b) 5 marks, (c) 5 marks, (d) 5 marks.
- 2, (a) 5 marks, (b) 5 marks, (c) 5 marks, (d) 5 marks
- 3, (a) 5 marks, (b) 5 marks, (c) 5 marks, (d) 5 marks
- 4, (a) 5 marks, (b) 5 marks, (c) 5 marks, (d) 5 marks
- 5, 20 marks.
- 6, 20 marks
- 7, (a) 10 marks, (b) 10 marks

## 98-MMP-B5, Mill Design & Operations

- 1, A 60" (152.4 cm) run-of-mine is directed at a rate of 1800 TPH to a crushing plant, which includes primary and secondary stages of crushing in open circuit and tertiary crushing in closed circuit. There is 29.84% undersize in the secondary crushing product and 70.12% undersize in the tertiary product. The final product is 1640 TPH at 80% passing ½" (1.27 cm), which is directed to a fine ore bin.
  - (a) Please select a primary crusher and horsepower required.
  - (b) Select number and size of secondary crusher and horsepower required.
  - (c) Select number and size of tertiary crusher and horsepower required.
  - (d) Indicate the material flow in each crushing stage and estimate the capital cost for all equipment required.
  
- 2, A pilot plant grinding circuit has a semi-autogenous mill-screen undersize being fed to the ball mill-cyclone circuit shown below:



The test data are summarized in the following:

Semi-autogenous mill:

Feed rate, tph	1.34
Feed size, 80% passing, $\mu\text{m}$ ,	75,000
Product size, 80% passing, $\mu\text{m}$ ,	420
Power draw, kw-hr per hr	9.35

Ball mill:

Feed rate, 53% of semi-autogenous mill	
Feed size, 80% passing, $\mu\text{m}$ ,	300
Product size, 80% passing, $\mu\text{m}$ ,	81
Power draw, kw-hr per hr	4.96

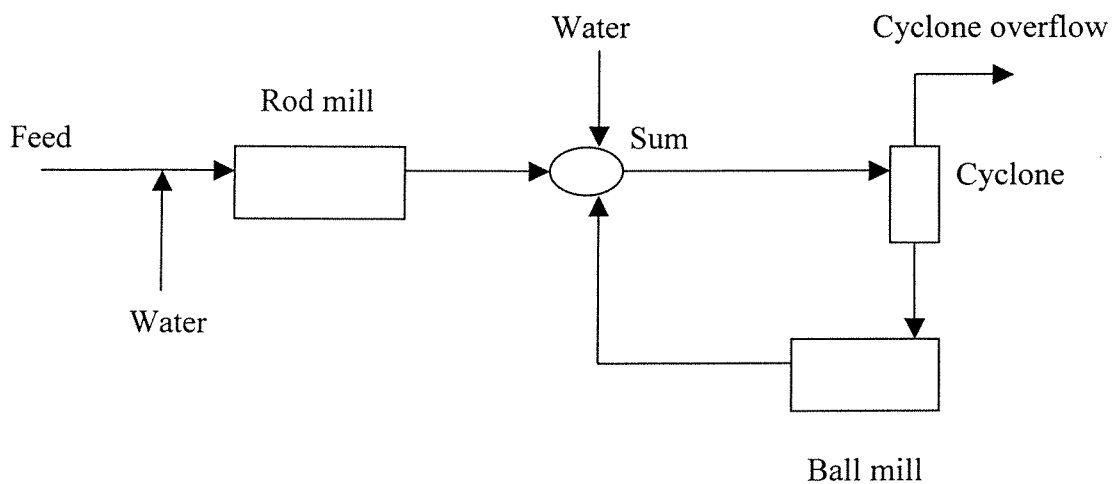
Please calculate:

- Power draw by semi-autogenous mill and its operating work index
  - Power draw by ball mill and its operating work index
  - Total power draw by semi-autogenous and ball mill
  - Overall operating work index.
- 3, A two stage grinding circuit as shown below is used in a gold mine at a capacity of 2,400 tonnes per day (dry ore). The specific gravity of the ore is 2.85. The feed from the fine ore bin is sampled and found to contain 5% moisture. Water is added in the circuit to make up the required pulp density, which is measured by mill operators every hour on the hour. The average pulp density at four points of the circuit is shown below:

Rod mill discharge	= 1638 g/L
Cyclone feed	= 1242 g/L
Cyclone underflow	= 1770 g/L
Cyclone overflow	= 1085 g/L

$$\% \text{ Solids by Weight} = \frac{S(D-1)}{D(S-1)}$$

Where: S = specific gravity, D = pulp density



The screen analysis of the cyclone feed and underflow are shown below:

<u>Screen Size</u>		<u>Cumulative Weight % Passing</u>	
<u>Mesh</u>	<u>µm</u>	<u>Feed</u>	<u>Underflow</u>
28	595	79.0	67.3
35	420	66.5	48.0
48	297	55.0	31.5
65	210	43.0	16.6
100	149	34.5	7.7
150	105	28.0	4.7
200	74	23.0	3.3
270	53	18.5	2.1
400	37	15.0	1.6

Calculate: (a) Circulating load and circulating load ratio  
 (b) Water added into rod mill feed  
 (c) Water added into cyclone feed pump  
 (d)  $D_{50}$  of the cyclone performance

- 4, A galena ore was ground and directed to a flotation rougher bank. A rougher concentrate was directed to a scavenger bank for improving the recovery. The scavenger tailing was discarded to tailing pond. Following data were collected for flotation plant design.

Feed	8.7% Pb at 1,000 tpd
Rougher concentrate	69.3% Pb
Rougher tailing	1.7% Pb
Scavenger concentrate	13.9% Pb
Scavenger tailing	0.4% Pb

Water/solid in rougher	2:1
Water/solid in scavenger	4:1
Flotation time in rougher	8 minutes
Flotation time in scavenger	15 minutes

Specific gravity of ore	2.8 g/mL
1 lb = 454.5 grams	
1,000 mL = 0.035 ft <sup>2</sup>	

- (a) Calculate tons of concentrate produced per day and recovery.  
 (b) The number of 100 ft<sup>3</sup> capacity Denver cell required for the rougher circuit  
 (c) Calculate the same for scavenger cells.  
 (d) What is the total cost of all flotation cell.

- 5, A copper-nickel ore was submitted for locked cycle test. The objective was to produce a copper-nickel rougher concentrate with a combined grade of Cu and Ni higher than 10%. The test result demonstrated that two cleaning stages were required and seven cycles were required to stay stable. The assay data and metals distribution are shown as the following table. Please use the results of last three (stable) cycles to predict the grade and recovery of the rougher concentrate.

Product	Weight		Assay		Distribution		Metal Unit	
	Grams	%	Cu%	Ni%	%Cu	%Ni	Cu	Ni
Cl. Con #1	125.69	1.80	6.61	7.56	13.23	11.83	11.8762	13.5890
Cl. Con #2	140.91	2.01	5.95	6.83	13.36	11.97	11.9906	13.7556
Cl. Con #3	170.51	2.44	5.24	5.91	14.22	12.54	12.7685	14.4021
Cl. Con #4	163.66	2.34	4.90	5.50	12.78	11.20	11.4716	12.8640
Cl. Con #5	168.08	2.40	5.22	5.84	13.97	12.21	12.5457	14.0262
Cl. Con #6	169.24	2.42	5.06	5.69	13.65	11.98	12.2548	13.7673
Cl. Con #7	169.10	2.42	5.10	5.73	13.74	12.06	12.3317	13.8574
1 <sup>st</sup> Cl Tail	68.78	0.98	0.53	1.01	0.58	0.86	0.5163	0.9933
2 <sup>nd</sup> Cl Tail	34.76	0.50	0.26	1.00	0.14	0.43	0.1272	0.4990
Ro Tail #1	821.71	11.75	0.05	0.23	0.65	2.32	0.5875	2.6672
Ro Tail #2	844.57	12.08	0.06	0.22	0.78	2.35	0.7004	2.7052
Ro Tail #3	828.32	11.84	0.05	0.22	0.62	2.25	0.5567	2.5820
Ro Tail #4	721.52	10.32	0.03	0.15	0.38	1.33	0.3405	1.5269
Ro Tail #5	909.06	13.00	0.05	0.23	0.69	2.61	0.6239	3.0027
Ro Tail #6	811.57	11.60	0.05	0.20	0.58	1.97	0.5222	2.2629
Ro Tail #7	845.97	12.10	0.05	0.20	0.63	2.07	0.5685	2.3830
Calc. Head	6993.45	100.00	0.90	1.15	100.00	100.00	89.7825	114.8840

- 6, A beach sand contains quartz, hematite, monazite, zircon, rutile and ilmenite. The physical property of these minerals can found and listed as below. Please suggest two possible flow sheets to produce the multi-concentrate products. Please compare the pro's and con's of the flow sheet suggest by you.

Mineral Name	Specific Gravity	Magnetic Response		Electrostatic Response	
		P	NM	C	NC
Quartz	2.7		X		X
Hematite	5.2	X		X	
Monazite	5,2	X			X
Zircon	4.7		X		X
Rutile	4.3		X	X	
Ilmenite	4.7	X		X	

Note: P = paramagnetic; NM = non-magnetic, C = conductor, NC = non-conductor

7.(a) Please describe the pro's and con's of following flotation circuits:

- (i) Mechanical flotation cell circuit.
  - (ii) Column flotation cell circuit.
  - (iii) Mechanical cell followed by column cell circuit.
  - (iv) Column cell followed by mechanical cell circuit.
- (b) You are assigned to select a flotation flow sheet to produce copper, lead, and zinc concentrates from a complex copper-lead-zinc sulfide ore. Please sketch two possible flotation flow sheets (selective and differential flotation) to treat this type of ore. Please compare the pro's and con's of the two potential flow sheets.

Year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030																																																																																										
Population	150,000,000	155,000,000	160,000,000	165,000,000	170,000,000	175,000,000	180,000,000	185,000,000	190,000,000	195,000,000	200,000,000	205,000,000	210,000,000	215,000,000	220,000,000	225,000,000	230,000,000	235,000,000	240,000,000	245,000,000	250,000,000	255,000,000	260,000,000	265,000,000	270,000,000	275,000,000	280,000,000	285,000,000	290,000,000	295,000,000	300,000,000	305,000,000	310,000,000	315,000,000	320,000,000	325,000,000	330,000,000	335,000,000	340,000,000	345,000,000	350,000,000	355,000,000	360,000,000	365,000,000	370,000,000	375,000,000	380,000,000	385,000,000	390,000,000	395,000,000	400,000,000	405,000,000	410,000,000	415,000,000	420,000,000	425,000,000	430,000,000	435,000,000	440,000,000	445,000,000	450,000,000	455,000,000	460,000,000	465,000,000	470,000,000	475,000,000	480,000,000	485,000,000	490,000,000	495,000,000	500,000,000	505,000,000	510,000,000	515,000,000	520,000,000	525,000,000	530,000,000	535,000,000	540,000,000	545,000,000	550,000,000	555,000,000	560,000,000	565,000,000	570,000,000	575,000,000	580,000,000	585,000,000	590,000,000	595,000,000	600,000,000	605,000,000	610,000,000	615,000,000	620,000,000	625,000,000	630,000,000	635,000,000	640,000,000	645,000,000	650,000,000	655,000,000	660,000,000	665,000,000	670,000,000	675,000,000	680,000,000	685,000,000	690,000,000	695,000,000	700,000,000	705,000,000	710,000,000	715,000,000	720,000,000	725,000,000	730,000,000	735,000,000	740,000,000	745,000,000	750,000,000	755,000,000	760,000,000	765,000,000	770,000,000	775,000,000	780,000,000	785,000,000	790,000,000	795,000,000	800,000,000	805,000,000	810,000,000	815,000,000	820,000,000	825,000,000	830,000,000	835,000,000	840,000,000	845,000,000	850,000,000	855,000,000	860,000,000	865,000,000	870,000,000	875,000,000	880,000,000	885,000,000	890,000,000	895,000,000	900,000,000	905,000,000	910,000,000	915,000,000	920,000,000	925,000,000	930,000,000	935,000,000	940,000,000	945,000,000	950,000,000	955,000,000	960,000,000	965,000,000	970,000,000	975,000,000	980,000,000	985,000,000	990,000,000	995,000,000	1,000,000,000
GDP	100,000,000,000	110,000,000,000	120,000,000,000	130,000,000,000	140,000,000,000	150,000,000,000	160,000,000,000	170,000,000,000	180,000,000,000	190,000,000,000	200,000,000,000	210,000,000,000	220,000,000,000	230,000,000,000	240,000,000,000	250,000,000,000	260,000,000,000	270,000,000,000	280,000,000,000	290,000,000,000	300,000,000,000	310,000,000,000	320,000,000,000	330,000,000,000	340,000,000,000	350,000,000,000	360,000,000,000	370,000,000,000	380,000,000,000	390,000,000,000	400,000,000,000	410,000,000,000	420,000,000,000	430,000,000,000	440,000,000,000	450,000,000,000	460,000,000,000	470,000,000,000	480,000,000,000	490,000,000,000	500,000,000,000	510,000,000,000	520,000,000,000	530,000,000,000	540,000,000,000	550,000,000,000	560,000,000,000	570,000,000,000	580,000,000,000	590,000,000,000	600,000,000,000	610,000,000,000	620,000,000,000	630,000,000,000	640,000,000,000	650,000,000,000	660,000,000,000	670,000,000,000	680,000,000,000	690,000,000,000	700,000,000,000	710,000,000,000	720,000,000,000	730,000,000,000	740,000,000,000	750,000,000,000	760,000,000,000	770,000,000,000	780,000,000,000	790,000,000,000	800,000,000,000	810,000,000,000	820,000,000,000	830,000,000,000	840,000,000,000	850,000,000,000	860,000,000,000	870,000,000,000	880,000,000,000	890,000,000,000	900,000,000,000	910,000,000,000	920,000,000,000	930,000,000,000	940,000,000,000	950,000,000,000	960,000,000,000	970,000,000,000	980,000,000,000	990,000,000,000	1,000,000,000,000																																																																																
Per Capita GDP	666.67	703.74	750.00	787.88	833.33	869.57	906.25	943.40	981.13	1,019.44	1,058.33	1,097.78	1,137.78	1,178.33	1,219.44	1,261.11	1,303.33	1,346.11	1,389.44	1,433.33	1,477.78	1,522.78	1,568.33	1,614.44	1,661.11	1,708.33	1,756.11	1,804.44	1,853.33	1,902.78	1,952.78	2,003.33	2,054.44	2,106.11	2,158.33	2,211.11	2,264.44	2,318.33	2,372.78	2,427.78	2,483.33	2,539.44	2,596.11	2,653.33	2,711.11	2,769.44	2,828.33	2,887.78	2,947.78	3,008.33	3,069.44	3,131.11	3,193.33	3,256.11	3,319.44	3,383.33	3,447.78	3,512.78	3,578.33	3,644.44	3,711.11	3,778.33	3,846.11	3,914.44	3,983.33	4,052.78	4,122.78	4,193.33	4,264.44	4,336.11	4,408.33	4,481.11	4,554.44	4,628.33	4,702.78	4,777.78	4,853.33	4,929.44	5,006.11	5,083.33	5,161.11	5,239.44	5,318.33	5,397.78	5,477.78	5,558.33	5,639.44	5,721.11	5,803.33	5,886.11	5,969.44	6,053.33	6,137.78	6,222.78	6,308.33	6,394.44	6,481.11	6,568.33	6,656.11	6,744.44	6,833.33	6,922.78	7,012.78	7,103.33	7,194.44	7,286.11	7,378.33	7,471.11	7,564.44	7,658.33	7,752.78	7,847.78	7,943.33	8,039.44	8,136.11	8,233.33	8,331.11	8,429.44	8,528.33	8,627.78	8,727.78	8,828.33	8,929.44	9,031.11	9,133.33	9,236.11	9,339.44	9,443.33	9,547.78	9,652.78	9,758.33	9,864.44	9,971.11	10,078.33																																					