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education

Department:
Education
REPUBLIC OF SOUTH AFRICA

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NOVEMBER 2006

NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINES AND WORKS

(8190306)

16 November (X-Paper)
09:00 – 12:00

Alpha-numeric or programmable calculators may NOT be used.

Only non-programmable calculators may be used.

CLOSED-BOOK EXAMINATION

This question paper consists of 9 pages, a psychrometric chart and a 1-page information sheet.

DEPARTMENT OF EDUCATION
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NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY
PLANT ENGINEERING:
MINES AND WORKS
TIME: 3 HOURS
MARKS: 100

NOTE: If you answer more than the required FIVE questions, only the first five questions will be marked. All work you do not want to be marked, must be clearly crossed out.

INSTRUCTIONS AND INFORMATION

1. This is NOT an open-book examination. Candidates are NOT allowed to use any notes, textbooks, references or cell phones during the examination.
2. Rule off on completion of each answer.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Answers written in pencil will NOT be marked. Illegible handwriting will NOT be marked.
5. Examination results will be disqualified if the candidate had NOT been accepted by the Commission of Examiners prior to the examination.
6. NO candidates arriving 30 minutes after the examination has started will be allowed to sit for the examination and NO candidate writing the examination, may leave the examination room before one hour after the commencement has elapsed.
7. Show ALL calculations.
8. Candidates may make reasonable assumptions where necessary.

SECTION A (COMPULSORY)

QUESTION 1

1.1 Discuss the function of an approved Code of Practice. (8)

1.2 You are the engineer on a mine and you have to select a suitable electrical cable for installation at the mine. Explain according to SANS 1507-1 the meaning of the following colour stripe markings on an electrical cable:

1.2.1 Red stripe marking (2)
1.2.2 Blue stripe marking (2)
1.2.3 White stripe marking (2)

1.3 A problem arises which requires your expertise, certain electrical globes in the store fail to operate when used for maintenance purposes, the following appears on the globe:

Explain what could be the possible reason for the malfunction of the globes. (6)
[20]

QUESTION 2

2.1 What is the function of a Lilly hoist controller? (6)

2.2 The following are particulars of a Koepe winder of the twin rope, tower mounted type:

Mass of conveyance	:	1 800 kg
Mass of material load	:	4 500 kg
Mass of balance weight	:	4 450 kg
Main and tail ropes	:	20 mm diameter; 1,88 kg/m
Angle of contact on rope of Koepe wheel	:	180°
Coefficient of friction on ropes on friction wheel	:	0,2
Length of each rope from friction wheel to the bottom of the loop in the tail rope	:	267 m

Determine the maximum rate of retardation which can be applied by the driver to control a descending, fully loaded conveyance, without causing the rope to slip. (14)
[20]

QUESTION 3

3.1 Two 2 200/110 V transformers are operated in parallel to share a load of 125 kVA at 0,8 power factor lagging. The transformers are rated as follows:

A : 100 kVA; 0,9% resistance and 10% reactance
B : 50 kVA; 1% resistance and 5% reactance

Calculate the load carried by each transformer. (6)

3.2 A three-phase transmission line supplies a load at 0,8 power factor lagging. The inductive reactors of the line 15 Ω/phase and the resistance are negligible. The line current is 1,1 kA and the voltage at both the sending and the load ends must be 330 kV, by means of synchronous capacitors at the receiving end.

Calculate the rating of the capacitors. (10)

3.3 Determine the maximum lifting speed of a crane with a 25 kW electrical motor for a load of 1 250 kg if the overall efficiency is 75%. (4)
[20]

TOTAL SECTION A: _____

SECTION B

Answer any TWO of the following six questions.

QUESTION 4

4.1 A pyrite-bearing solution must be heated from 20 °C to 80 °C at a rate of 2,1 t/h in a tubular contra-flow heat exchanger. Hot air enters the exchanger at 350 °C and a rate of 2,36 t/h.

Calculate the following:

4.1.1 The number of 25 mm inside diameter tubes if the solution velocity is limited to 17 mm/s (8)

4.1.2 The length of the tubes (4)

The specific heat of the hot air is 1,05 kJ/kg.K. The heat transfer coefficient, gas to metal, is 34 W/m^{2}K and metal to water is 6 kW/m^{2}K. The temperature drop through the metal may be neglected. The specific heat capacity and density of the solution are 3,8 kJ/kg.K and 1,21 t/m^3.

4.2 During a test on a four-stroke single cylinder oil engine, the following data and results were obtained:

Indicated mean effective pressure	:	567 kPa
Swept volume of cylinder	:	14 litres
Speed of engine	:	6,6 r/s
Effective brake load	:	77 kg
Effective brake radius	:	0,7 m
Fuel consumption	:	0,002 kg/s
Calorific value of fuel	:	44 MJ/kg
Cooling water circulation	:	0,15 kg/s
Cooling water inlet temperature	:	38 °C
Cooling water outlet temperature	:	71 °C
Specific heat capacity of water	:	4,18 kJ/kg.K
Energy to exhaust gases	:	33,6 kJ/s

Determine the indicated and brake outputs and the mechanical efficiency. (8)
[20]

QUESTION 5

5.1 The estimated short-circuit VA at the bus bars of a generating station is 1 000 MVA and another station is 660 MVA. The generated voltage of each station is 11 kV.

Calculate the possible short-circuit VA at each station when they are linked by an interconnector cable with a reactance of 0,4 Ω. (14)

5.2 A three-phase overhead transmission line, 5 km long, must supply 2 MW at 6,6 kV. The power factor is 0,85.

If the power loss is not to exceed 7%, calculate the minimum cross section of the conductor.

Let the resistivity of the copper cable be $0{,}017 \times 10^{-6}$ Ω/m. (6)
[20]

QUESTION 6

6.1 A new drive system must be installed in a metallurgical plant with the following specifications:

'n 600 mm diameter pulley driven by a horizontal belt transmits power through a solid shaft to a 262 mm diameter pinion which drives a mating gear. The pulley weighs 1 200 N to provide some flywheel effect. The arrangement of parts, the belt tensions and the components of the gear reactions on the pinion, are indicated in the figure (FIGURE 1) below.

Determine the necessary shaft diameter using a suitable value for commercial shafting and shock fatigue factors of $K_b = 2$, $K_t = 1,5$ and the allowable shear stress is 40 MPa.

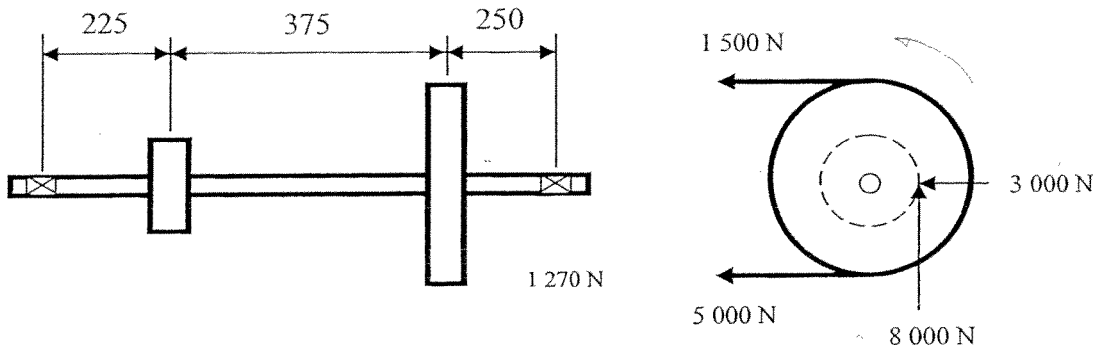

FIGURE 1 (14)

6.2 A vibrating screen in a crusher plant has three closely coiled extension springs. It is decided to modify the structure to accommodate four identical closely coiled extension springs. The total loaded mass of the screen is 3,54 t.

Calculate the suitable dimensions for the manufacture of such springs.

The C = D/d ratio is 5,88, the maximum torsional stress is 450 MPa and the modulus of rigidity is 80 GPa. The extension under load must not exceed 155 mm per spring. There is no initial tension in the wire.

Calculate the following:

6.2.1 The diameter of the wire (3)

6.2.2 The mean coil diameter (1)

6.2.3 The number of coils (2)

[20]

QUESTION 7

7.1 Calculate the motor power required to drive a coal conveyor belt and the minimum and maximum tensions in the conveyor belt given:

Centre distance between tail and head pulleys	:	250 m
Vertical lift	:	20 m
Capacity of conveyor belt	:	300 t/h
Belt speed	:	1,2 m/s
Drive pulley angle of wrap, single lagged	:	210°
Coefficient of friction	:	0,3
Friction factor of empty belt	:	0,0345
Friction factor of loaded belt	:	0,04
Mass of empty belt moving parts	:	36 kg/m
Drive efficiency	:	75%

(10)

7.2 A clear water centrifugal pump installation in a gold reduction plant, has a negligible suction head. The pump delivers 220 m^3/h through a delivery pipe that is 30 m long, 156 mm in diameter and has a vertical lift of 26 m. The friction factor for the pipe is 0,01. Exactly midway along the length of the delivery pipe, a short pipe branches out from the delivery pipe. The branch pipe which is closed by means of a valve, is at an elevation of 12 m above the centrifugal pump. The valve is opened to a stage where the discharge at the end of the delivery pipe is reduced to 135 m^3/h, while 100 m^3/h of water is discharged through the branch pipe. At flow rates of 220 m^3/h and 235 m^3/h, the pump efficiency is 78% and 77% respectively.

Determine the following:

7.2.1 The power required to drive the pump while the valve in the branch pipe is fully closed (4)

7.2.2 The power required to drive the pump while the discharge from the branch pipe is 100 m^3/h. Assume that the loss in the branch pipe is negligible (6)

[20]

QUESTION 8

8.1 During the testing of an uncooled centrifugal air compressor, the following measurements were taken:

Inlet pressure	:	100 kPa abs.
Inlet temperature	:	20 °C
Discharge pressure	:	500 kPa abs.
Discharge temperature	:	221 °C
Mass flow of air	:	600 kg/min
Energy absorbed by the motor	:	2 300 kW
Specific heat capacity at constant pressure	:	1,005 kJ/kg.K
Isentropic compression index	:	1,4

Calculate the following:

8.1.1 The adiabatic efficiency of the compressor (5)

8.1.2 The mechanical efficiency of the compressor if the motor efficiency is 93% (5)

8.2 Air conditioning has to be applied to the air supplied to a working place of a mine laboratory. The working place receives 15 kg/s of air at a barometric pressure of 95 kPa and dry bulb and wet bulb temperatures of 31 °C and 28 °C respectively. The plant can remove 750 kW heat and at least 160 g/s of moisture.

Establish, from the psychrometric chart provided, the maximum temperature and relative humidity of the incoming air. (Write your examination number on the psychrometric chart and hand it in with your ANSWER BOOK.) (10)
[20]

QUESTION 9

9.1 In a dryness fraction test using a combined separating-throttling calorimeter, the pressure in the mains was 550 kPa and 0,12 kg water was collected in the separating calorimeter in the same time as 10,8 kg steam was condensed at the exit from the throttling calorimeter.

The manometer on the throttling calorimeter showed a pressure of 100 kPa. The temperature shown on the thermometer in the calorimeter was 110 °C.

The sensible heat at 550 kPa is 656 kJ/kg and the latent heat at the same pressure is 2 097 kJ/kg.

Determine the dryness fraction of the steam in the mains. (10)

9.2 An underground refrigerating unit consists of an evaporator, compressor, condenser and a throttling regulator. The pressure limits in the cycle are 0,491 MPa and 1 219 MPa. The heat transfer from the condenser unit to the bulk air in the return airway is 100 MJ/h. The refrigerant is assumed dry saturated at the beginning of compression and to have a temperature of 55 °C after compression. At the end of the condensation the refrigerant is liquid but not under cooled. The specific heat capacity of the superheated vapour is 0,705 kJ/kg.K.

Determine the following:

9.2.1 The mass flow of the refrigerant in kg/h assuming no energy loss (4)

9.2.2 The dryness of the refrigerant at entry to the evaporator (3)

9.2.3 The power of the driving motor if the efficiency is 70% (3)

Pressure (MPa)	**t_{sat} (°C)**	**Specific enthalpy (kJ/kg)**		**Specific entropy (kJ/kg.K)**	
		Liquid	**Vapour**	**Liquid**	**Vapour**
0,491	15	50,1	193,8	0,1915	0,6902
1,219	50	84,9	206,5	0,3037	0,6797

[20]

TOTAL: 100

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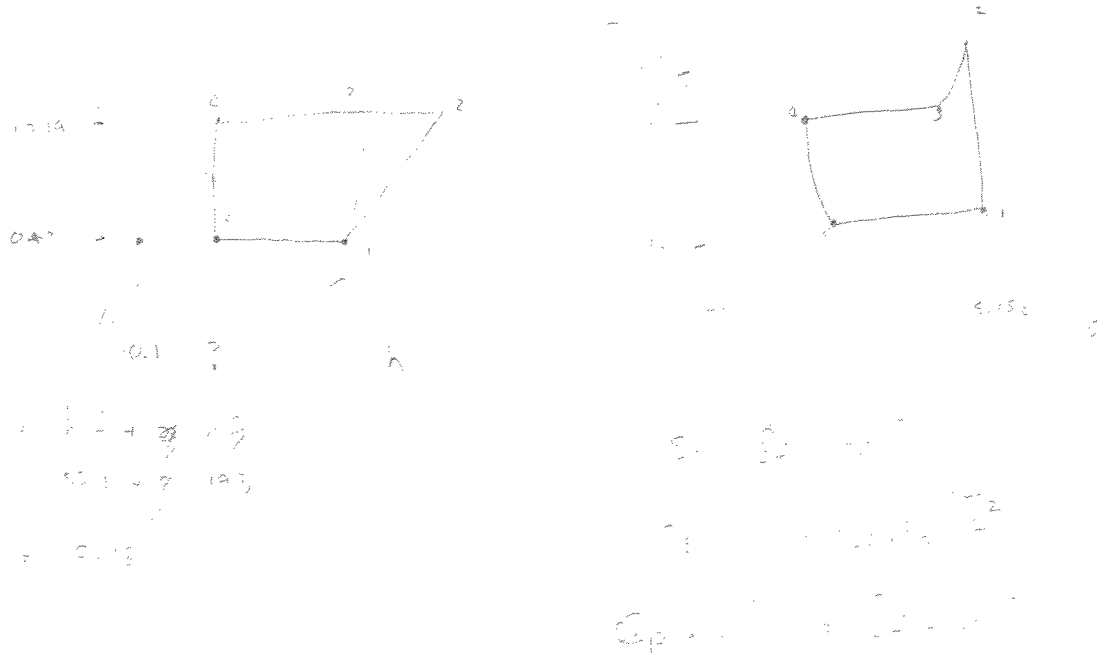
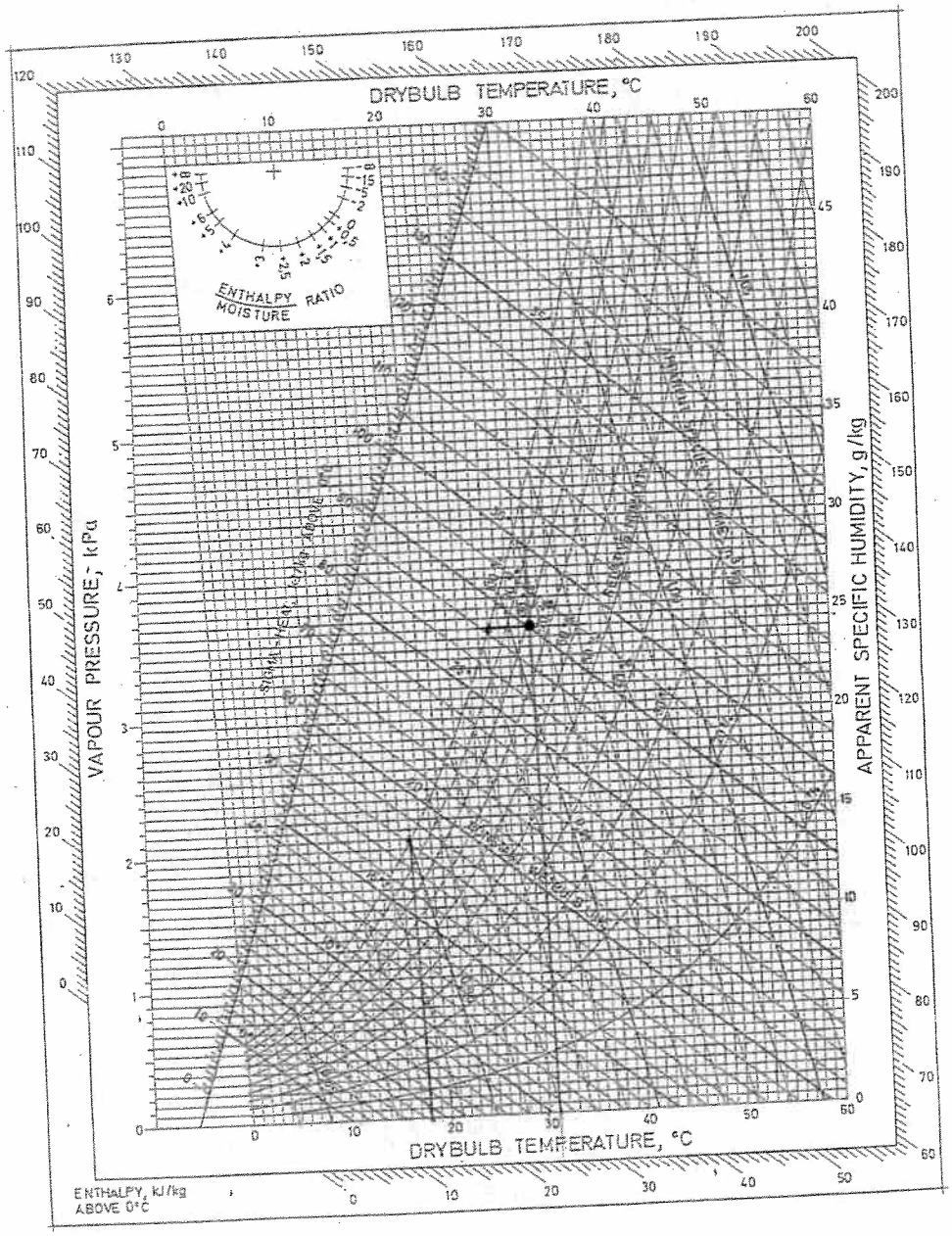


EXAMINATION NUMBER:

PSYCHROMETRIC CHART

95,0 kPa



PLANT ENGINEERING: MINES AND WORKS

FORMULAES

$$P = \sqrt{3}\, V\, I\, Cos\, \theta$$

$$Q = mC\Delta t$$

$$P = (T_1 - T_2)\, v$$

$$P = mgLSin\, \theta$$

$$P = \mu mgL$$

$$M = fz$$

$$hf = \frac{4fLv^2}{2gd}$$

$$h = \frac{k\, v^2}{2g}$$

$$pv = mRT$$

$$\frac{M}{I} = \frac{\sigma}{Y} + \frac{E}{R}$$

$$M = \frac{WL^2}{8}$$

$$M = \frac{WL}{4}$$

$$M = \sigma Z$$

$$Z = \frac{I}{Y}$$

$$I_{XX} = \frac{bd^3}{12}$$

$$T_1 / T_2 = e^{\mu\theta}$$

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{Ln\ (\Delta T_1 / \Delta T_2)}$$

$$Q = U \times A \times LMTD$$

$$IP = PLACE$$

$$BP = 2\pi Tn$$

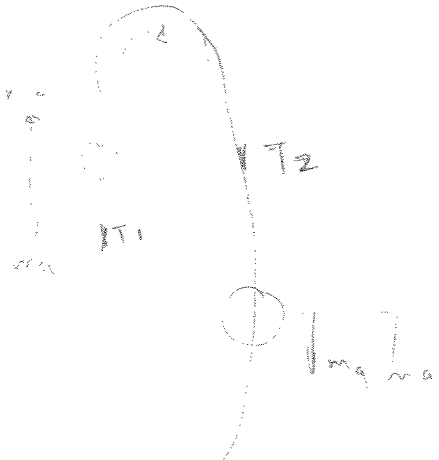
$$\Delta = 8FD^3 n / Gd^4$$

$$\tau_{\max} = kFD8 / \pi d^3$$

$$k = \frac{4(C-1)}{4(C-4)} + \frac{0{,}165}{C}$$

$$C = D / d$$

$$\Delta = 8FD^3 n / Gd^4$$



$T_1 = mg - ma$

$(4440 + 2 \times 1.88 \times 267)$

5844

$= 57\,323 - 5844a$

$T_2 = mg + ma$

$= 2 \times 1.88 \times 267 + 1800 + 4000$

7304

$T_2 = 71651 + 7304a$

$\frac{T_2}{T_1} = e^{\mu\theta}$

$71651 + 7304a = 1.87\,(53503 - 5844a)$

$71651 + 7304a = 100\,050 - 10\,199a$

$=$