higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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JUNE EXAMINATION

NATIONAL CERTIFICATE

PLANT ENGINEERING: FACTORIES

(8190316)

9 June 2014 (X-Paper)
09:00–12:00

Alpha-numerical or programmable calculators may NOT be used.

Only non-programmable calculators may be used.

CLOSED-BOOK EXAMINATION

This question paper consists of 8 pages, 1 formula sheet and 2 profile sheets.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NON-NATIONAL CERTIFICATE: ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: FACTORIES

TIME: 3 HOURS

MARKS: 100

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

INSTRUCTIONS AND INFORMATION

1. Answer QUESTION 1, QUESTION 2 and QUESTION 3 in SECTION A and any TWO questions in SECTION B.
2. ALL the calculations must be shown.
3. NO marks will be given for calculations in which the steps cannot be clearly followed or for work completed in pencil.
4. Candidates are expected to make reasonable assumptions where necessary and these, together with any formulae used, must be clearly stated.
5. Rule off on completion of EACH answer before starting the answer to a new question.
6. Number the answers according to the numbering system used in this question paper.
7. Write neatly and legibly.
8. This is NOT an OPEN-BOOK EXAMINATION. Candidates are NOT allowed to use any notes, textbooks, references books or cellphones during the examination.
9. Candidates, who were NOT accepted by the Commission, will be disqualified.
10. NO candidates may enter the examination room after half an hour after the start of the examination and NO candidate may leave the examination room before one hour has elapsed.

SECTION A (COMPULSORY)

QUESTION 1

1.1 You have a 10 ton fire-tube steam generator that uses coal at your plant.

Name TEN items to be checked or to be done every 8 hours on the steam generator. (10)

1.2 A tank containing 400 kg of paraffin is to be heated from 10 °C to 40 °C in 20 minutes (1 200 seconds) at your factory where polish is manufactured, using 400 kPa (gauge) steam. The paraffin has a specific heat capacity of 2.0 kJ/kg °C over that temperature range. The h_{fg} at 400 kPa (gauge) is 2 108.1 kJ/kg. The tank is well insulated and heat losses are negligible.

Determine the steam flow rate. (10)
[20]

QUESTION 2

A single-phase motor operating from a 240 V, 50 Hz supply is developing 10 kW with an efficiently of 84 per cent and a power factor of 0,7 lagging.

Calculate:

2.1.1 the input kilovolt amperes (3)

2.1.2 the active and reactive components of the current (3)

2.1.3 the reactive kilovolt amperes (or kilovars) (2)

2.1.4 the capacitance required in parallel to raise the power factor to 0,9 lagging (6)

2.2 Discuss common mistakes that cause wastage of electrical energy in electrical motors. (6)
[20]

QUESTION 3

3.1 A health and safety management system (OHSMS) prescribed by the chief inspector in government notice R.859 of 2 September 2005 requires that you must establish an occupational health and safety policy.

Name FIVE requirements that should be contained in the employer's OHS policy. (5)

3.2 A 10 ton centrifugal press is used to make 10 mm holes in small 5 mm plates that are manually fed.

3.2.1 Name FIVE items or documents on the press to be considered for the planning stage of an OHSMS. (5)

3.2.2 Name FIVE hazards associated with such a press and give the precautionary measures to reduce the hazards. (5 x 2) (10)

[20]

TOTAL SECTION A: 60

SECTION B

Answer any TWO of the following five questions.

QUESTION 4

4.1 Name FOUR safety considerations to determine the nominal cross-sectional area of a conductor in an electrical installation. (4)

4.2 Where may flexible cords be used in an electrical installation? (4)

4.3 What information must be on a multicore, extruded solid dielectric-insulated cable? (3)

4.4 Name TWO requirements for the marking of multicore, extruded solid dielectric-insulated cables. (2)

4.5 Name SEVEN requirements for outdoor storage of cable drums. (7)

[20]

QUESTION 5

5.1 Routine inspection of a 305 x 165 x 40,5 rolled steel joist (RSJ) installed in a factory as a cantilevered crawl beam for a lifting machine reveals a crack in the top flange. The direction of the crack is at right angles to the longitudinal axis of the RSJ.

Non-destructive testing methods are used and a crack of 9 mm long completely through the top flange is found 2,45 m from the free end of the cantilever.

Factory records reveal the RSJ has a:

(i) yield stress of 350 MPa
(ii) fracture toughness, Kic = 70 MPa.$\sqrt{m}$
(iii) thickness-to-width ratio factor for the flanges of 1,25
(iv) minimum factor of the safety of 4 in its application.

The crack is found towards the end of a major and expensive maintenance shutdown and factory refit. The availability of the lifting machine is absolutely essential for the completion of the refit. Repair or replacement of the crawl beam, because it is extremely awkwardly situated, will mean the loss of a number of days. These delays will result in many thousands of rands of additional expense.

An attempt must be made to avoid, with safety in consideration, repair or replacement of the RSJ until the factory refit is completed. Determine, according to the Critical Stress Intensity Theory, the maximum load (in kg) which may be applied to the free end of the cantilever with a factor of safety of 4. The crack reduces the effective second moment of area of the RSJ by 2,3%.

(10)

5.2 A new feed water tank has to be constructed for the steam generator house of a factory. The tank must have a capacity of 5 000 litres of water and is to be cubic in shape. The tank is to be made from 2,5 mm thick 3Cr12 plate with a density of 7 700 kg/m^3 and be supported on 4 channel-section support legs, with the bottom of the tank 5 metres above the steam generator house floor. The weight of the fittings and attachments is 162 kg. The support legs are to be concreted into the steam generator house floor. To maximise access to the floor space under the tank there can be no cross-bracing between the legs. The tank rests on the legs and is not restrained in any direction. Each support leg is to have a factor of safety of 4.

Take Young's Modulus for the steel as 206 GPa and the yield stress as 250 MPa.

Select from structural steel tables, by means of calculations based on the Euler theory, the most economical section of the channel to use.

(10)
[20]

QUESTION 6

A three-phase, 6 600 volt feeder supplies power exclusively to a pump station consisting of a number of pump- and motor units. When all the original pump- and motor units operate simultaneously the feeder carries a load of 1 000 kVA at a power factor of 0,8 lagging.

An additional 600 kVA synchronous motor is installed in the pump station to drive an extra pump. When run unloaded this motor absorbs 60 kW. The pump to be powered by the synchronous motor requires 270 kW to drive it. The motor efficiency is 90% when delivering 270 kW.

6.1 Calculate, when all the original pumps are in operation and the synchronous motor is driving its pump, the

6.1.1 line current in the feeder and (10)

6.1.2 power factor of the feeder at the pump station. (1)

6.2 Determine, when all the original pumps are in operation and the synchronous motor is uncoupled from its pump and runs unloaded, the

6.2.1 line current in the feeder and (8)

6.2.2 power factor of the feeder at the pump station. (1)
[20]

QUESTION 7

7.1 The simple lifting machine shown in FIGURE 1 is used to raise a series of loads. These loads, with their corresponding required efforts, are shown in the table below.

Load	250 N	500 N	750 N
Effort	72 N	142 N	212 N

Determine:

7.1.1 The velocity ration of the machine in the sketch

7.1.2 The law of this machine

7.1.3 The mechanical advantage and the efficiency of this machine when lifting the 250 N load

7.1.4 The maximum efficiency attainable by the machine

7.1.4 The maximum load that can be raised if the maximum applied effort is 700 N

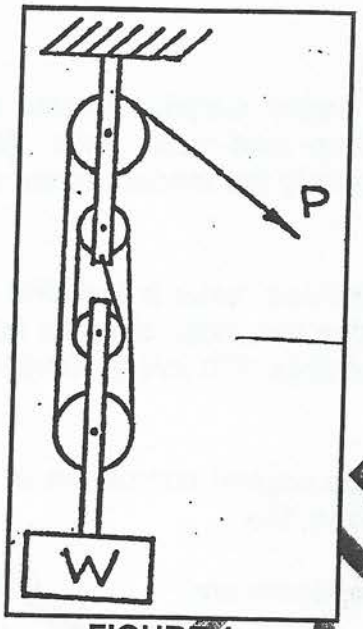


FIGURE 1

(9)

7.2 A horizontal beam, with a weight of 100 kN, rests on two supports and is loaded as shown in FIGURE 2.

By what distance and in what direction should the uniformly distributed load be shifted if it is required that the reaction at the supports should be equal?

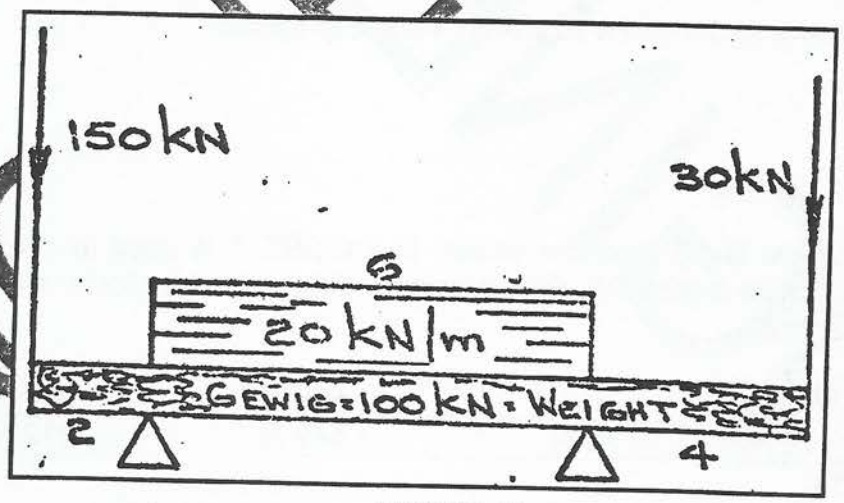


FIGURE 2

(11)
[20]

QUESTION 8

8.1 A battery of 120 cells, has an overcharge current I equal to 17 A, in a room of dimensions 4 m x 2 m x 3 m, on a stand where the battery and stand are occupying approximately 3 m^3.

8.1.1 Calculate the concentration gas in the room after 1 hour.

$V = N \times I \times 0{,}00045\ m^3$

8.1.2 If the concentration of hydrogen must be below 0,8 %, what should the change rate be?

(2 x 3) (6)

8.2 You have a battery room for the charging of forklift batteries that is classified as a zone 2 hazardous location.

Name FOUR types of protection that may be used on the electrical machinery. (4)

8.3 Name SIX areas where cathodic protection is successfully used. (6)

8.4 Name FOUR areas where cathodic protection is not generally used. (4)

[20]

TOTAL SECTION B: 40
GRAND TOTAL: 100

FORMULA SHEET

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

$Q = mC\Delta t$

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

$P = mgL\sin\theta$

$P = \mu mgL$

$M = f\, z$

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

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

$pv = mRT$

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

$M = \frac{wL^2}{2}$

$M = WL$

$M = \sigma Z$

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

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

$I_{xx} = \frac{\pi(D^4 - d^4)}{64}$

$z = \frac{\pi(D^4 - d^4)}{32D}$

$T/h = CW^2\rho v$

$Q = \frac{UA(\emptyset_1 - \emptyset_2)}{Ln(\emptyset_1/\emptyset_2)}$

$W = \frac{n}{n-1} P_1V_1 \{(P_2/P_1)\exp[(n-1)/n] - 1\}$

$V_{sphere} = \frac{\pi D^3}{6}$

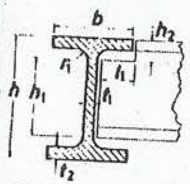
$\Delta V_{sphere} = \frac{\pi PD^4}{8tE}(1 - v)$

$\Delta P = \frac{32\,\mu LV}{D^2}$

$F_E = \frac{n\,\pi^2 EI}{L^2}$

$K_{ic} = Y.s.\sqrt{(\pi.c)}$

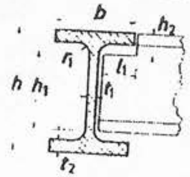
PROFILE SHEETS



I – PROFIELE
Parallelflens

AFMETINGS VIR DETAILLERING

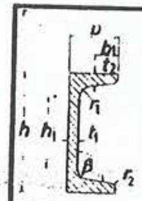
Reeksgrootte Serial Size mm	ρ_l kg/m	h mm	r_1 mm	Flens/Flange b mm	Flens/Flange t_2 mm	Web t_1 mm	Web h_1 mm	Web $\frac{t_1}{2}+2$ mm	Keep/Notch t_1 mm	Keep/Notch h_2 mm
203 X 133	25,3	203,2	7,6	133,4	7,8	5,8	172	4,9	75	20
	29,8	206,8	7,6	133,8	9,6	6,3	172	5,2	75	20
254 X 146	31,3	251,5	7,6	146,1	8,6	6,1	219	5,1	85	20
	37,2	256,0	7,6	146,4	10,9	6,4	219	5,2	85	25
	43,2	259,6	7,6	147,3	12,7	7,3	219	5,7	85	25
305 X 102	24,5	304,8	7,6	101,6	6,8	5,8	276	4,9	60	20
	28,6	308,9	7,6	101,9	8,9	6,1	276	5,1	60	20
	32,8	312,7	7,6	102,4	10,8	6,6	276	5,3	60	25
305 X 165	40,5	303,8	8,9	165,1	10,2	6,1	266	5,1	90	25
	46,1	307,1	8,9	165,7	11,8	6,7	266	5,4	90	25
	53,6	310,9	8,9	166,8	13,7	7,7	266	5,9	90	25
356 X 171	44,8	352,0	10,2	171,0	9,7	6,9	312	5,5	95	25
	50,7	355,6	10,2	171,5	11,5	7,3	312	5,7	95	25
	56,7	358,6	10,2	172,1	13,0	8,0	312	6,0	95	30
	67,2	364,0	10,2	173,2	15,7	9,1	312	6,6	95	30
406 X 140	38,6	397,3	10,2	141,8	8,6	6,3	360	5,2	80	25
	46,3	402,3	10,2	142,4	11,2	6,9	360	5,5	80	25
406 X 178	53,8	402,6	10,2	177,6	10,9	7,6	360	5,8	100	25
	59,8	406,4	10,2	177,8	12,8	7,8	360	5,9	100	30
	67,2	409,4	10,2	178,8	14,3	8,8	360	6,4	100	30
	74,8	412,8	10,2	179,7	16,0	9,7	360	6,9	100	30



I – SECTIONS
Parallel Flange

DIMENSIONS FOR DETAILING

Reeksgrootte Serial Size mm	ρ_l kg/m	h mm	r_1 mm	Flens/Flange b mm	Flens/Flange t_2 mm	Web t_1 mm	Web h_1 mm	Web $\frac{t_1}{2}+2$ mm	Keep/Notch l_1 mm	Keep/Notch h_2 mm
457 X 191	67,1	453,6	10,2	189,9	12,7	8,5	408	6,3	105	25
	74,7	457,2	10,2	190,5	14,5	9,1	408	6,6	105	30
	82,0	460,2	10,2	191,3	16,0	9,9	408	7,0	105	30
	89,7	463,6	10,2	192,0	17,7	10,6	408	7,3	105	30
	98,3	467,4	10,2	192,8	19,6	11,4	408	7,7	105	35
533 X 210	82,2	528,3	12,7	208,7	13,2	9,6	477	6,8	110	30
	92,5	533,1	12,7	209,3	15,6	10,2	477	7,1	110	35
	101	536,7	12,7	210,1	17,4	10,9	477	7,5	110	35
	109	539,5	12,7	210,7	18,8	11,6	477	7,8	110	35
	122	544,6	12,7	211,9	21,3	12,8	477	8,4	110	40
610 X 229 1)	101	602,2	12,7	227,6	14,8	10,6	547	7,3	120	30
	113	607,3	12,7	228,2	17,3	11,2	547	7,6	120	35
	125	611,9	12,7	229,0	19,6	11,9	547	8,0	120	35
	140	617,0	12,7	230,1	22,1	13,1	547	8,6	120	40
610 X 305 1)	149	609,6	16,5	304,8	19,7	11,9	537	8,0	160	40
	179	617,5	16,5	307,0	23,6	14,1	537	9,1	160	45
	238	633,0	16,5	311,5	31,4	18,6	537	11,3	160	50
686 X 254 2)	125	677,9	15,2	253,0	16,2	11,7	615	7,9	135	35
	140	683,5	15,2	253,7	19,0	12,4	615	8,2	135	40
	152	687,6	15,2	254,5	21,0	13,2	615	8,6	135	40
	170	692,9	15,2	255,8	23,7	14,5	615	9,3	135	45



KANAALPROFIELE

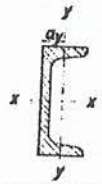
AFMETINGS EN EIENSKAPPE

Grootte Size	ρ_l	h	b	t_1	t_2	r_1	r_2	b_1	h_1	β	A
mm	kg/m	mm	mm	mm	mm	mm	mm	mm	mm	grade degrees	10^{-3} m^2
80 X 45 1)	8,64	80	45	6	8	8	4	22,5	46,6	94,57	1,102
100 X 50 1)	10,6	100	50	6	8,5	8,5	4,5	25,6	64,3	94,57	1,345
120 X 55 1)	13,4	120	55	7	9	9	4,5	27,5	82,1	94,57	1,699
140 X 60 1)	16,0	140	60	7	10	10	5	30,0	97,9	94,57	2,037
160 X 65 1)	18,8	160	65	7,5	10,5	10,5	5,5	32,5	116	94,57	2,401
180 X 70 1)	22,0	180	70	8	11	11	5,5	35,0	133	94,57	2,797
200 X 75 1)	25,3	200	75	8,5	11,5	11,5	6	37,5	151	94,57	3,218
220 X 80 1)	29,4	220	80	9	12,5	12,5	6,5	40,0	167	94,57	3,744
240 X 85 1)	33,2	240	85	9,5	13	13	6,5	42,5	185	94,57	4,231
260 X 90 1)	37,9	260	90	10	14	14	7	45,0	201	94,57	4,828
280 X 95 1)	41,8	280	95	10	15	15	7,5	47,5	216	94,57	5,342
300 X 100 1)	46,2	300	100	10	16	16	8	50,0	232	94,57	5,876
380 X 102 2)	63,1	380	102	13,5	16	16	8	44,3	313	92,86	8,041
400 X 110 2)	71,8	400	110	14	18	18	9	48,0	325	92,86	9,152
76 X 38 2)	6,70	76,2	38,1	5,1	6,8	7,6	2,4	16,5	45,7	95	0,853
127 X 64 2)	14,9	127,0	63,5	6,4	9,2	10,7	2,4	28,5	84,1	95	1,898
152 X 76 2)	17,9	152,4	76,2	6,4	9,0	12,2	2,4	34,9	106	95	2,282
178 X 54 2)	14,5	177,8	54,0	5,8	8,3	8,3	3,2	24,1	144	92	1,856
381 X 102 2)	55,1	381,0	101,6	10,4	16,3	15,2	4,8	45,6	312	95	7,019

1) $b_1 = \frac{b}{2}$

2) $b_1 = \frac{b - t_1}{2}$

CHANNELS



DIMENSIONS AND PROPERTIES

Grootte Size	a_y	om as/about axis x-x: I	om as/about axis x-x: Z_e	om as/about axis x-x: i	om as/about axis y-y: I	om as/about axis y-y: Z_e	om as/about axis y-y: i	C	$\frac{h}{t_2}$
mm	mm	10^{-6} m^4	10^{-6} m^3	mm	10^{-6} m^4	10^{-6} m^3	mm	10^{-9} m^4	
80 X 45 1)	14,5	1,059	26,48	31,0	0,1936	6,351	13,3	21,25	10,0
100 X 50 1)	15,5	2,053	41,07	39,1	0,2915	8,450	14,7	27,87	11,8
120 X 55 1)	16,0	3,643	60,72	46,3	0,4306	11,06	15,9	40,94	13,3
140 X 60 1)	17,5	6,048	86,40	54,5	0,6249	14,72	17,5	56,46	14,0
160 X 65 1)	18,4	9,247	115,6	62,1	0,8505	18,25	18,8	73,45	15,2
180 X 70 1)	19,2	13,54	150,4	69,6	1,136	22,38	20,1	94,06	16,4
200 X 75 1)	20,1	19,11	191,1	77,1	1,478	26,94	21,4	118,8	17,4
220 X 80 1)	21,4	26,91	244,6	84,8	1,959	33,45	22,9	159,7	17,6
240 X 85 1)	22,3	35,99	299,9	92,2	2,474	39,50	24,2	196,0	18,6
260 X 90 1)	23,6	48,24	371,1	100,0	3,173	47,84	25,6	254,6	18,6
280 X 95 1)	25,3	62,76	448,3	108,4	3,982	57,15	27,3	310,2	18,7
300 X 100 1)	27,0	80,28	535,2	116,9	4,931	67,56	29,0	376,5	18,8
380 X 102 2)	23,8	157,6	829,2	140,0	6,153	78,74	27,7	609,5	23,7
400 X 110 2)	26,8	203,5	1018	149,1	8,511	102,3	30,5	819,0	22,2
76 X 38 2)	11,9	0,737	19,38	29,4	0,1060	4,064	11,2	12,40	11,2
127 X 64 2)	19,6	4,845	76,31	50,5	0,6845	15,42	19,0	49,03	13,8
152 X 76 2)	22,0	8,445	111,1	60,9	1,129	20,92	22,3	59,39	16,9
178 X 54 2)	13,6	8,697	96,60	68,1	0,4306	10,67	15,2	34,40	21,5
381 X 102 2)	25,3	149,1	782,8	145,7	5,849	76,24	28,9	459,4	23,4