GAUTENG DEPARTMENT OF EDUCATION

SENIOR CERTIFICATE EXAMINATION

FEB / MAR 2006

TECHNIKA (MECHANICAL) HG

TIME: 3 hours

MARKS: 300

REQUIREMENTS:

- Calculator, drawing instruments and information pamphlet.

INSTRUCTIONS:

- Answer **ALL** questions.

QUESTION 1

1.1 Give the correct name for the following hydrocarbon compounds in the alkane series:

1.1.1 C_3H_8 (2)

1.1.2 C_5H_{12} (2)

1.2 Name THREE basic crystal forms of steel. (3)

1.3 Most metals crystallize to one of three types of space-lattice. Write down the name and atomic number of each type. (6)

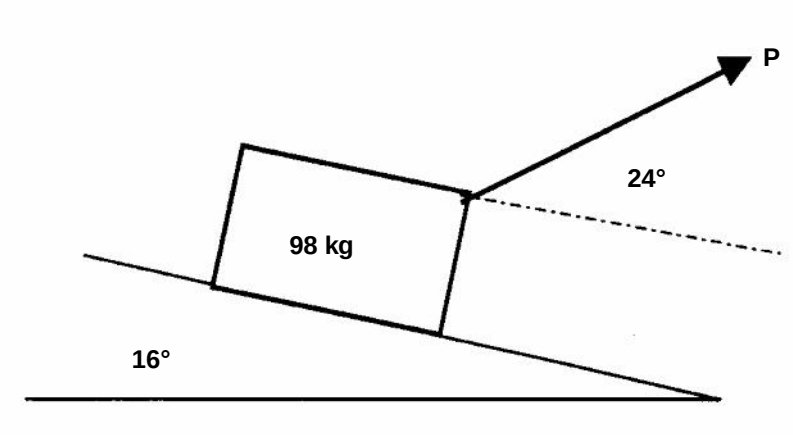
1.4 A spiral spring is 120 mm long. A force of 7 N is needed to stretch the spring by 10 mm. Calculate the work required when the spring is stretched from 130 mm to 150 mm. The limit of elasticity of the spring is not exceeded. (5)

1.5 Briefly describe the following tests and illustrate your answer with the aid of simple sketches.

1.5.1 The Brinell hardness test (8)

1.5.2 The Rockwell hardness test (8)

1.6 A body with a mass of 98 kg is placed on an inclined plane making an angle of 16° with the horizontal. The coefficient of friction is 0,36. Calculate the magnitude of the smallest force **P** required to pull the object **down** the incline.



(10)

1.7 Draw a schematic diagram of a single epicyclic gear train. Show and label the following components:

1.7.1 Sun gear

1.7.2 Planet gears

1.7.3 Planet-gear carrier

1.7.4 Planetary ring gear (6)

[50]

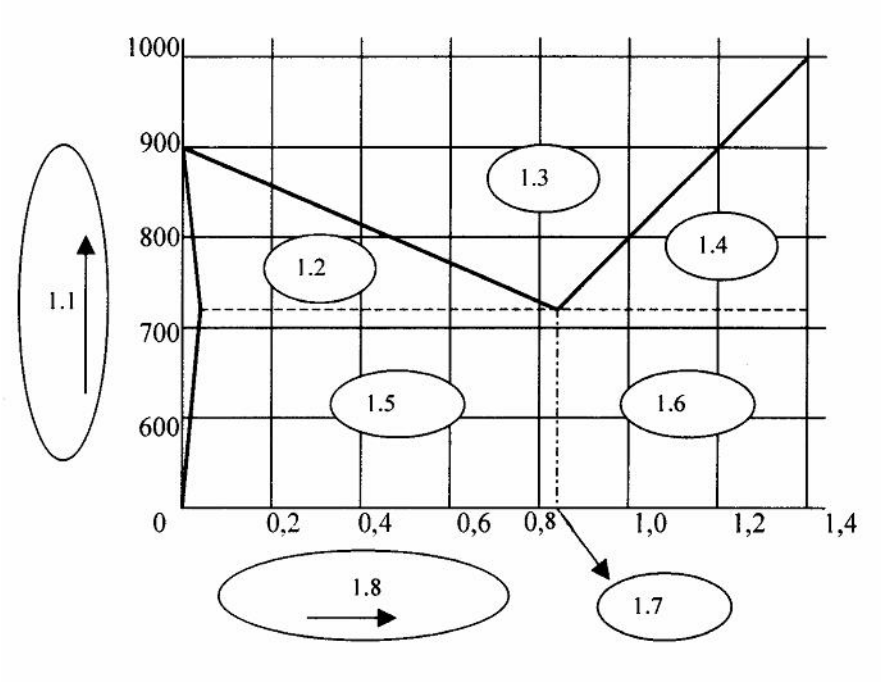
QUESTION 2

2.1 A lift has a steel cable of 25,26 mm diameter and an elastic modulus E of 200 x GPa. The cable is 25 metres long when the lift is at ground level. Calculate the distance the lift will lower below ground level due to the extension of the cable, when a mass of 700 kg is loaded into the lift. (12)

2.2 Draw a typical stress strain graph obtained when low carbon steel (mild steel) is subject to a destructive tensile test. Label all the components of the graph. (8)

2.3 The engine of a motor vehicle develops a torque of 715 Newton metres at 3 200 revolutions per minute. Calculate the brake power of the engine. (5)

2.4 Name the following components of the iron-carbon equilibrium diagram. Also determine with the aid of the diagram, to what temperature steel with a carbon content of 1% must be heated to reach its upper critical temperature. (AC3)



(10)

2.5 A vehicle, with a mass of 760 kg, accelerates uniformly from rest to 90 km/h in 8 s up an incline of 1:20. The frictional resistance is 250 N.

Calculate

2.5.1 the work done against the frictional force when the velocity has reached 90 km/h. (5)

2.5.2 the work done against the gravitational component parallel to the plane. (3)

2.5.3 the total force exerted by the vehicle. (5)

2.6 Define **velocity**. (2)

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QUESTION 3

3.1 The following data is provided for a six-cylinder four-stroke internal combustion engine:

Cylinder diameter	96 mm
Stroke	110 mm
Mean effective pressure on piston	978 kPa
Revolutions per minute	3 600 rpm
Effective brake-arm length	1 200 mm
Reading on scale	16,5 kg

Calculate the following:

3.1.1 The indicated power in kW (7)

3.1.2 The work done during **one** power stroke if the piston moves from the TDC to the BDC (3)

3.1.3 The brake power in kW (4)

3.1.4 The mechanical efficiency of the engine (3)

3.2 Draw a neat, labelled sketch of a Pröney brake used to test brake power. (8)

3.3 Describe the X-ray test used to test steel for defects. (4)

3.4 The power transmitted by a drive belt from a drive-pully with a diameter of 400 mm rotating at 3 200 revolutions per minute, is 12 kW. The ratio of the tractive force in the tight side to that in the slack side is 2,5:1.

Calculate

3.4.1 the tractive force in the tight side of the belt. (10)

3.4.2 the belt speed in metres per second. (3)

3.5 Briefly describe what happens to the structure of steel at the following halting points of the carbon iron equilibrium diagram:

3.5.1 **AC_1** (5)

3.5.2 **AC_3** (3)

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QUESTION 4

4.1 Describe the concept **Ergonomics**. (4)

4.2 What is the function of a social worker? (2)

4.3 Name FOUR characteristics of a good operations leader. (4)

4.4 Name the responsibilities of the employer with regard to industrial hygiene. (4)

4.5 Prove that 1 radian is equal to 57,3°. (3)

4.6 The mass of a flywheel is 72 kg and the radius of inertia is 330 mm. The flywheel is accelerated from 180 rpm to 2 340 rpm in 8 seconds.

Calculate

4.6.1 the angular acceleration in radians per second^2. (4)

4.6.2 the accelerating torque. (4)

4.6.3 the moment of inertia. (4)

4.6.4 the kinetic energy when the flywheel rotates at 2 340 rpm. (5)

4.7 The included angle of an M50 V-screw thread with a pitch of 6 mm is 70,2°. Calculate the distance over the large and small measuring wires.

Given:

Maximum diameter of measuring wires 1,01 P
Minimum diameter of measuring wires 0,5 P (10)

4.8 Use the table of primary selection of fits in the information pages and give the following:

4.8.1 The limits for a **26H7-g6** hole-shaft combination (4)

4.8.2 The type of fit (2)

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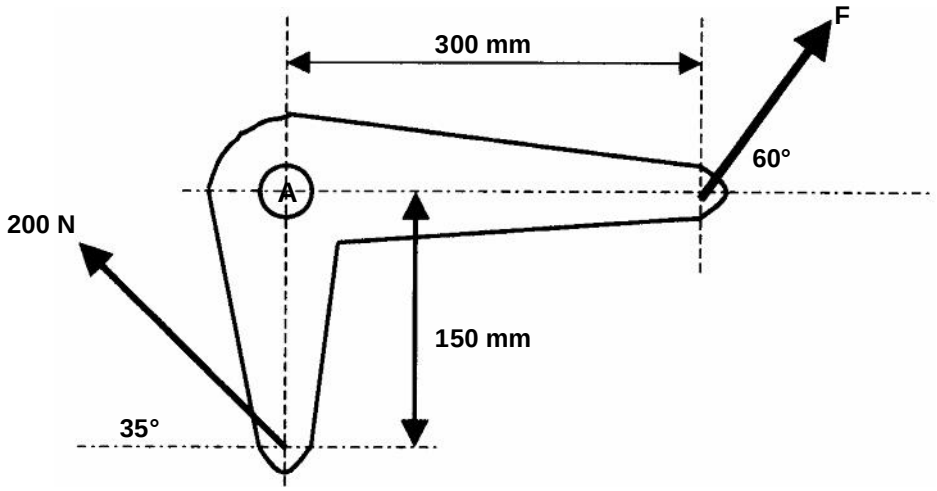
QUESTION 5

5.1 Calculate the magnitude of the reaction at pivot point **A** of the lever that is in equilibrium.



(16)

5.2 One hundred and thirty-seven (137) teeth must be milled on a spur gear. The dividing head ratio is 40:1.

5.2.1 Calculate the indexing required. (Choose 140 divisions.) (2)

5.2.2 Calculate the change wheels required. (5)

5.2.3 Determine the direction of rotation of the index plate. (2)

5.2.4 Draw a simple sketch clearly showing the position and arrangement of the change wheels. (4)

5.3 Define the following concepts:

5.3.1 Potential energy (3)

5.3.2 Kinetic energy (3)

5.4 The volume of a certain gas is 3,6 m^3 at a pressure of 138 kPa and a temperature of 20° C. Calculate the final temperature in °C if the volume of the gas is reduced to 2,1 m^3 at a pressure of 750 kPa. (5)

5.5 Give the **law of Boyle**. (4)

5.6 Define the **law of Pascal**. (4)

5.7 Define **thermodynamics** as a branch of physics. (2)

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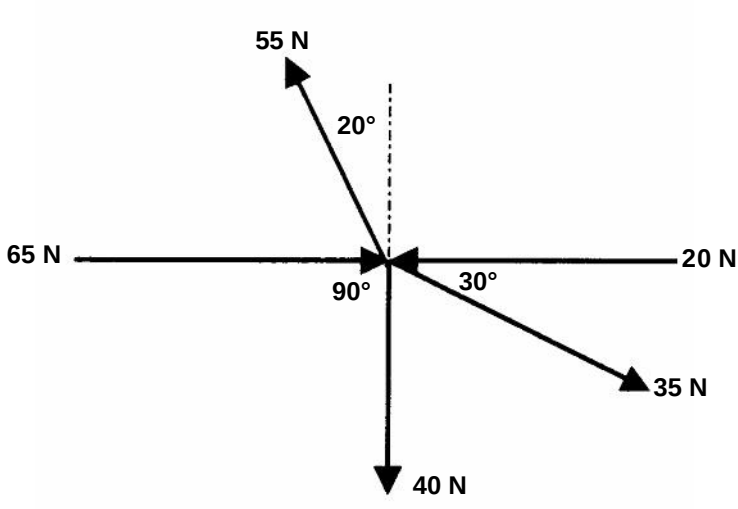
QUESTION 6

6.1 The diagram below shows FOUR forces acting at a point. Calculate the magnitude and direction of the equilibrium force.



(18)

6.2 Define **equilibrium force**. (4)

6.3 What is the purpose of a pressure-relief valve in a hydraulic system? (1)

6.4 Name the components of which the power unit in a hydraulic system consists. (3)

6.5 The following components were used in the design of a hydraulic system for a car hoist:

- Electric motor
- Hydraulic gear pump
- Ventilated reservoir
- Non-adjustable pressure relief valve
- Adjustable pressure relief valve
- Shut-off valves
- Check valve (one way)
- Two-way control valve (spring loaded)
- Measuring vessel
- Single acting power cylinder
- Pressure gauge
- Filter

Use I.S.O. 1219 symbols and design a flow diagram for the hoist. (12)

6.6 Describe the operation of a helical-spring single-plate dry clutch during disengagement of the input shaft from the output shaft. (9)

6.7 Which THREE conditions are important before work can be done? (3)

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TOTAL: 300

INFORMATION PAGES / INLIGTINGSBLADSYE

1. **Tooth gears for milling machine / Tandratte vir freesmasjien**
   Standard and special wheels / Standaard- en spesiale wiele

   24 (two of these / twee van hierdie); 28; 32; 40; 44; 46; 47; 48; 52; 56; 58; 64; 68; 70; 72; 76; 84; 86 and/en 100 teeth / tande

2. **Index plate for milling machine / Indeksplaat vir freesmasjien**

   Standard Cincinnati index machine / Standaard-Cincinnati-indeksmasjien 24; 25; 28; 30; 34; 37; 38; 39; 41; 42; 43; 46; 47; 49; 51; 53; 54; 57; 58; 59; 62 and/en 66 holes/gate

3. **Take π = 3,14 / Neem π = 3,14**

4. **Take g = 10 m.s^{-2} / Neem g = 10 m.s^{-2}**

5. **Formulae / Formules**

   5.1 Indexing / Indeksering:

   5.1.1 Simple indexing / Eenvoudige indeksering = $\frac{40}{N}$

   [Dr = Drive gear / Dryfrat]
   [Dn / Gd = Driven gear / Gedrewe rat]

   5.1.2 Differential indexing / Differensiaal-indeksering = $\frac{Dr}{Gdr} = \frac{(A-N)}{A} \times \frac{40}{1}$

   5.2 Two-wire method of screw-thread measurement / Tweedraad-metode van skroefdraad-meting:

   Calculation of included angle / Berekening van ingeslote hoek:

$$\sin \frac{?}{2} = \frac{R-r}{\frac{(M-m)}{2} + r - R}$$

   5.3 Friction: Co-efficient of friction / Wrywing: Wrywingskoëffisiënt $\mu = \frac{F}{R}$

   5.4 Stress / Spanning = $\frac{f}{A}$

5.5 Cross-sectional area of solid cylinder / Dwarsdeursnee-area van soliede silinder = $\frac{pD^2}{4}$

5.6 Cross-sectional area of hollow cylinder / Dwarsdeursnee-area van hol silinder = $\frac{p(D^2 - d^2)}{4}$

5.7 $E = \frac{\text{Stress}}{\text{Strain}}$ /E = $\frac{\text{Spanning}}{\text{Vormverandering}}$

5.8 Strain = $\frac{\text{Change in length}}{\text{Original length}}$ /Vormverandering = $\frac{\text{Verandering in lengte}}{\text{Oorspronklike lengte}}$

5.9 Factor of Safety = $\frac{\text{Ultimate stress}}{\text{Working stress}}$ /Veiligheidsfaktor = $\frac{\text{Breekspanning}}{\text{Werkspanning}}$

5.10 Angular acceleration / Hoekversnelling = $\frac{?_2 - ?_1}{t}$

5.11 Torque T / Draaimoment $T = mk^2?^2$

5.12 Moment of inertia / Traagheidsmoment $I = mk^2$

5.13 Angular velocity / Hoeksnelheid $? = \frac{2\pi n}{60}$

5.14 Kinetic energy of a flywheel / Kinetiese energie van ? vliegwiel $E_k = \frac{1}{2} mk^2?^2$

5.15 Belt drives / Bandaandrywings

5.15.1 Power P / Drywing $P - (T_1 - T_2)\ \pi\ Dn$

5.15.2 $D_{Dr} \times N_{Dr} = D_{Dn} \times N_{Dn}$ (Dr = Driver pulley)
(Dn = Driven pulley)

$D_{Dr} \times N_{Dr} = D_{Gdr} \times N_{Gdr}$ (Dr = Dryfkatrol)
(Gdr = Gedrewe katrol)

5.16 Gear drives / Rataandrywings

5.16.1 $N_A \times T_A = N_B \times T_B$

5.16.2 $\frac{\text{Revolutions of final driven gear}}{\text{Revolutions of first drive gear}}$ / $\frac{\text{Omwentelinge van finale gedrewe rat}}{\text{Omwentelinge van eerste dryfrat}}$

=

$\frac{\text{Product of number of teeth on all drive gears}}{\text{Product of number of teeth on the driven gears}}$ / $\frac{\text{Produk van getal tande op al die dryfratte}}{\text{Produk van getal tande op die gedrewe ratte}}$

5.16.3 Speed ratio = $\frac{\text{Product of number of teeth on all drive gears}}{\text{Product of number of teeth on all driven gears}}$

Spoedverhouding = $\frac{\text{Produk van getal tande van alle dryfratte}}{\text{Produk van getal tande van alle gedrewe ratte}}$

5.17 Power / Drywing

5.17.1 Indicated power IP = pLANn (N = Number of power strokes per second)
Aangeduide drywing AD = pLANn (N = Getal kragslae per sekonde)

5.17.2 Brake power BP / Remdrywing RD = $\frac{2\pi NT}{60}$

5.17.3 Torque T / Draaimoment T = Fr

5.17.4 Mechanical efficiency = $\frac{BP}{IP} \times \frac{100}{1}$ /Meganiese rendement $\frac{RD}{AD} \times \frac{100}{1}$

5.18 Motion equations / Bewegingsvergelykings

$v = u + at$	$v = at$	$v = u + gt$	$v = gt$
$s = ut + \frac{1}{2} at^2$	$s = \frac{1}{2} at^2$	$s = ut + \frac{1}{2}gt^2$	$s = \frac{1}{2}gt^2$
$v^2 = u^2 + 2as$	$v^2 = 2as$	$v^2 = u^2 + 2gs$	$v^2 = 2gs$

6. Table of primary fits (hole-basis system) / *Tabel van primêre passings (gatbasis-stelsel)*

Nominal sizes *Nominale groottes*		CLEARANCE FITS *VRY PASSINGS*												TRANSITION FITS *OORGANGPASSINGS*				INTERFERENCE FITS *SLUITPASSINGS*			
		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*		Tolerance *Toleransie*	
Over *Oor* mm	To *Tot* mm	H11	c11	H9	d10	H9	e9	H8	F7	H7	g6	H7	h6	H7	k6	H7	n6	H7	p6	H7	s6
UNIT / *EENHEID* 0,001 mm																					
10	18	+ 110	- 95	+ 41	- 50	+ 43	- 32	+ 27	- 16	+ 18	- 6	+ 18	- 11	+18	+ 12	+18	+ 23	+ 18	+ 29	+ 18	+ 39
		0	- 205	0	- 120	0	- 75	0	- 34	0	- 17	0	0	0	+ 1	0	+ 12	0	+ 18	0	+ 28
18	30	+ 130	- 110	+ 52	- 65	+ 52	- 40	+ 33	- 20	+ 21	- 7	+ 21	- 13	+ 21	+ 15	+ 21	+ 28	+ 21	+ 35	+ 21	+ 48
		0	- 204	0	- 149	0	- 92	0	- 41	0	- 20	0	0	0	+ 2	0	+ 15	0	+ 22	0	+ 35
30	40	+ 160	- 120																		
		0	- 280	+ 62	- 80	+ 62	- 50	+ 39	- 25	+ 25	- 9	+ 25	- 16	+ 25	+ 18	+ 25	+ 33	+ 25	+ 42	+ 25	+ 59
40	50	+ 160	- 130	0	- 180	0	- 112	0	- 50	0	- 25	0	0	0	+ 2	0	+ 17	0	+ 26	0	+ 43
		0	- 290																		

Selection of Primary Fits (hole-basis system)
Seleksie van Primêre Passings (gatbasis-stelsel)