SENIOR CERTIFICATE EXAMINATION

FEBRUARY / MARCH

2007

TECHNIKA (MECHANICAL)

HG

715-1/0 E

TECHNIKA MECHANICAL HG

715 1 0E HG

12 pages

X05

GAUTENG DEPARTMENT OF EDUCATION

SENIOR CERTIFICATE EXAMINATION

TECHNIKA (MECHANICAL) HG

TIME: 3 hours

MARKS: 300

REQUIREMENTS:

- Calculator, drawing instruments and information pages.

INSTRUCTIONS:

- Answer **ALL** questions.
- Sketches and diagrams must be large, neat and labelled.
- All calculations must be shown.
- Answers must be clearly numbered, according to the numbering used on the question paper.
- Information pages (pages 9 – 12) are provided at the end of the paper.

QUESTION 1

1.1 State FOUR facets which are important for successful work stream planning. (4)

1.2 Define a **radian**. (4)

1.3 Define the following concepts:

1.3.1 The mean effective pressure on the piston of an internal combustion engine (4)

1.3.2 Indicated power (4)

1.4 Name TWO advantages and TWO disadvantages of gear drives. (4)

1.5 Calculate the required indexing for an angle of **3º40´** on a Cincinnati dividing head. (6)

1.6 A body with a mass of 17 kg is at rest on a horizontal plane. A horizontal force of 12 N is applied and the resistance against motion is 9 N. If the body is displaced 48 m during a period of 32 s, calculate the

1.6.1 work done by the resistance force. (3)

1.6.2 work changed to kinetic energy. (3)

1.6.3 total work done. (3)

1.6.4 total power. (3)

1.7 Define the terms **pitch** and **lead** of a screw-thread. (4)

1.8 Draw a neat sketch of a Prony brake system used to determine the brake power of an engine. Label all components. (8)

[50]

QUESTION 2

2.1 A mass of 50 kg is accelerated up an incline making an angle of 15° with the horizontal, from 4 m/s to 18 m/s during a period of 20 s. The coefficient of friction is 0,25. Calculate the

2.1.1 acceleration. (3)

2.1.2 distance travelled. (3)

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

2.1.4 frictional force. (3)

2.1.5 work done against the frictional force. (3)

2.1.6 work done converted to kinetic energy. (3)

2.1.7 power delivered by the total force. (5)

2.2 State FIVE elements of a screw thread. (5)

2.3 State THREE basic crystal structures of steel. (3)

2.4 Most metals crystallize to one of three types of space lattice arrangements. State the name and atomic number of each type. (6)

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

2.5.1 AC_1 (5)

2.5.2 AC_2 (2)

2.5.3 AC_3 (3)

2.6 Prove that one revolution is equal to 2 π radians. (3)

[50]

QUESTION 3

3.1 Define each of the following:

3.1.1 Hooke's Law (4)

3.1.2 Boyle's Law (4)

3.1.3 1 Joule (4)

3.2 Name FOUR possible causes of belt slippage. (4)

3.3 What is the purpose of a key in a transmission system? (2)

3.4 Study **Figure 1** and answer the questions that follow.

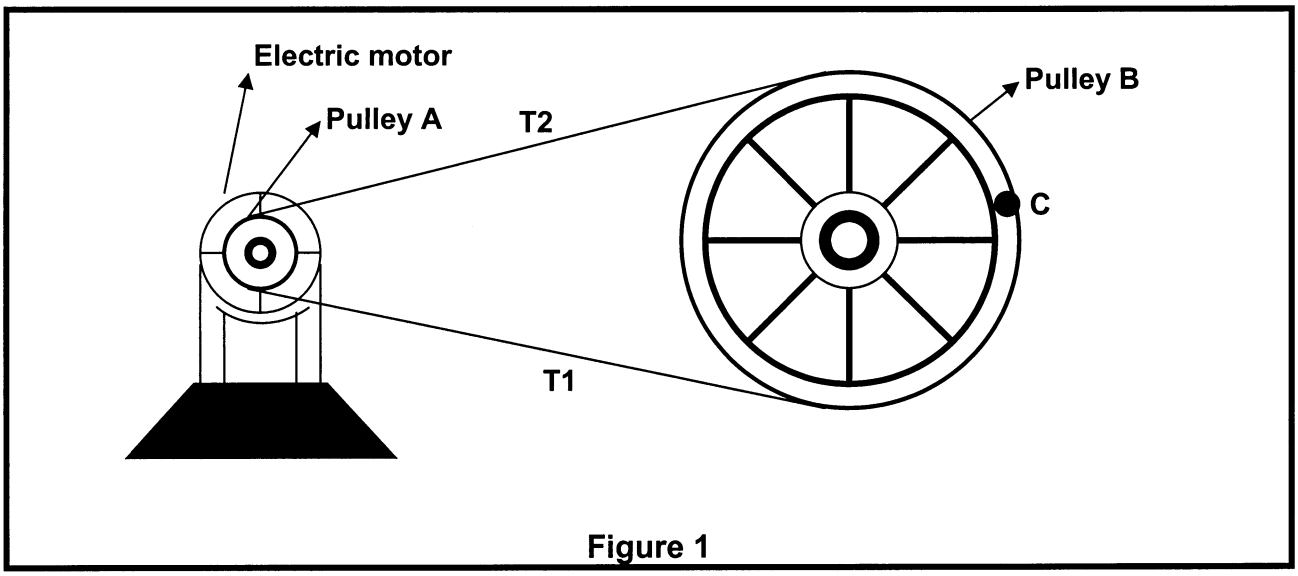


Figure 1

Information:

- Rotational frequency of electric motor: 1 200 r.p.m.
- Diameter of pulley A: 230 mm
- Diameter of pulley B: 620 mm
- Forces in T1: 400 N
- Ratio between T1 and T2: 2

3.4.1 If pulley **A** makes TWO revolutions, calculate the angle (in radians) through which point **C** on the circumference of pulley **B** will move. (8)

3.4.2 Calculate the

(a) power transmitted by the electric motor. (7)
(b) velocity ratio. (3)
(c) circumference speed of the pulley. (4)

3.5 Define each of the following:

3.5.1 Velocity (3)

3.5.2 A vector (3)

3.5.3 Power (2)

3.5.4 Thermodynamics (2)
[50]

QUESTION 4

4.1 The volume of a certain gas is 3,2 m^3 at a pressure of 137 kPa and a temperature of 25° C. Calculate the final temperature in °C if the volume of the gas is reduced to 0,8 m^3 by a pressure of 580 kPa. (5)

4.2 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

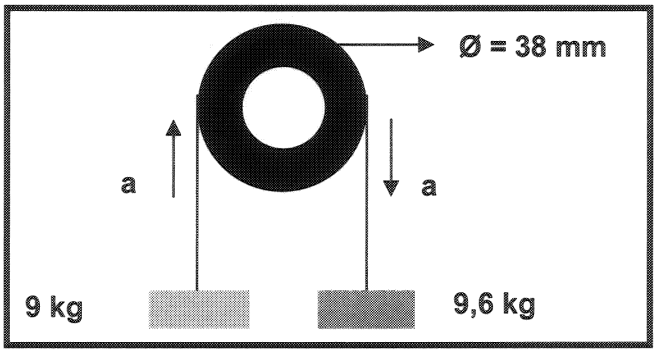
Use I.S.O 1219 symbols and design a flow diagram for the hoist. (12)

4.3 A spiral spring is 150 mm in length. A force of 8 N stretches it 10 mm. Calculate the work done when the spring is stretched from 160 mm to 210 mm. The limit of elasticity is not exceeded. (5)

4.4 A lightweight string is passed over a frictionless pulley and is attached to two masses, one of 9 kg and one of 9,6 kg. Calculate the

4.4.1 acceleration of the masses.

4.4.2 force in the string.



(8)

4.5 Use the table of primary fits in the information pages, and state the following:

4.5.1 The limits for a 28H7-p6 hole-shaft combination (4)

4.5.2 The type of fit (1)

4.5.3 The allowance for this fit (3)

4.6 The included angle of a M50 V-screw thread with a pitch of 6 mm is 68°. Calculate the distance over the large and small measuring wires.
Given:

Maximum diameter of measuring wires 1,01P
Minimum diameter of measuring wires 0,505P (10)

4.7 Describe **organic chemistry**. (2)
[50]

QUESTION 5

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

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

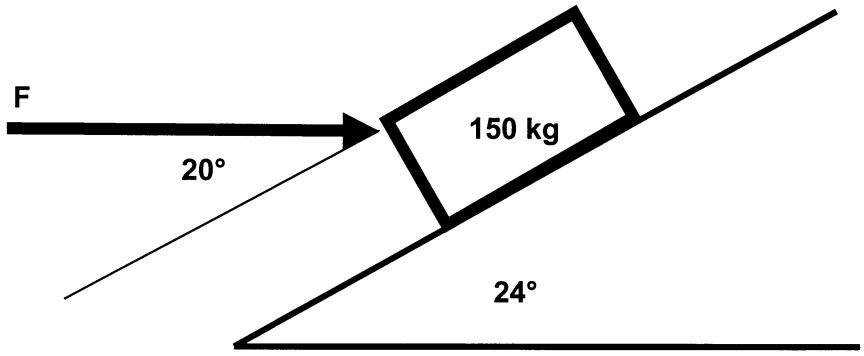
5.1.2 Calculate the change wheels required. (5)

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

5.1.4 Draw a simple sketch to indicate the position and arrangement of the change wheels. (4)

5.2 Describe the ultrasonic test used to test steel for defects. (6)

5.3 A body with a mass of 150 kg is placed on an inclined plane making an angle of 24° with the horizontal. The coefficient of friction is 0,4. Calculate the magnitude of the smallest force **F** that will push the object UP the incline if **F** forms an angle of 20° with the incline.



(10)

5.4 The following data is provided for an internal combustion engine tested by means of a Prony brake:

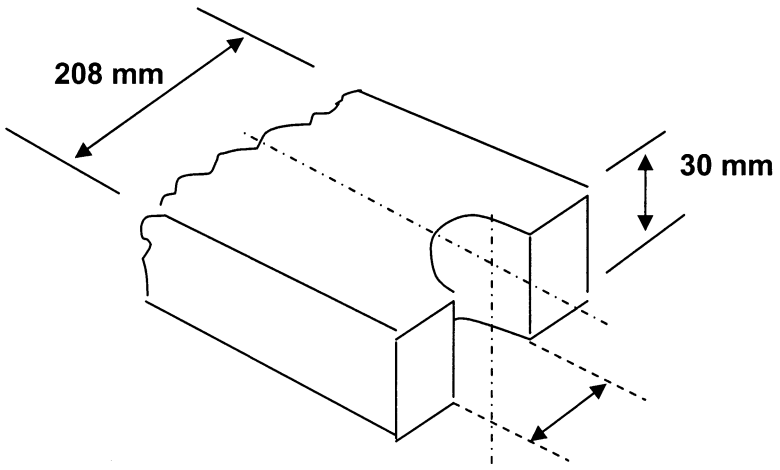
Length of brake arm	:	1 300 mm
Revolutions per minute	:	3 600
Indicated power	:	140 kW
Scale reading	:	18 kg

Calculate the

5.4.1 brake power of the engine in kW. (5)

5.4.2 mechanical efficiency of the engine. (3)

5.5 Calculate the size of the rivet hole that must be drilled on the centre line if the pull bar can withstand a pull stress of 60 MPa. The load on the pull bar is 230 kN.



(10)

5.6 Name THREE properties of an ideal gas. (3)

[50]

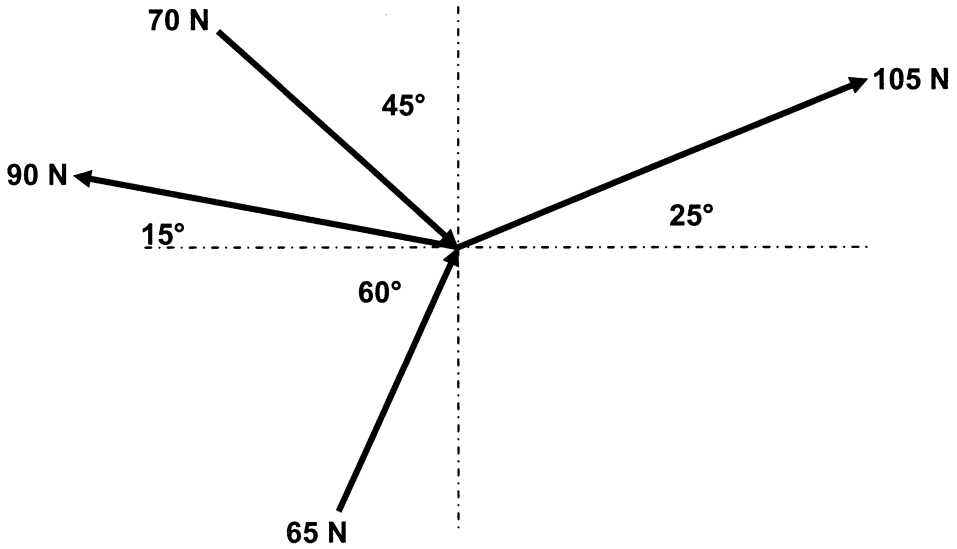
QUESTION 6

6.1 A uniform beam of 85 kg is 18 m long and rests horizontally on two supports. The one support is at the left end and the other support is 4 m from the right end. The beam carries concentrated loads of 320 N and 150 N respectively 5 m and 10 m from the left end. The beam also carries an evenly distributed load of 12 N/m over the first 6 m from the right end. Calculate the reactions at the supports and test your answer. (14)

6.2 State the **law of moments**. (4)

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

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



(18)

6.5 Name THREE industrial diseases and give the causes of each. (6)

[50]

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 / Differensiaalindeksering = $\frac{Dr}{Gdr} = \frac{(A-N)}{A} \times \frac{40}{1}$

   5.2 Two-wire method of screw-thread measurement / Tweedraadmetode van skroefdraadmeting:

   Calculation of included angle / Berekening van ingeslote hoek:

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

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

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

5.5 Cross-sectional area of solid cylinder / Dwarsdeursnee-area van soliede silinder = $\frac{\pi D^2}{4}$ or / *of* πr^2

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

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 = $\frac{\omega_2 - \omega_1}{t}$

5.11 Torque T / Draaimoment $T = mk^2\omega^2$

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

5.13 Angular velocity / Hoeksnelheid $\omega = \frac{2\pi N}{60}$

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

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 = $\frac{BP}{IP} x \frac{100}{1}$ /Meganiese rendement $\frac{RD}{AD} x \frac{100}{1}$

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 *STUITPASSINGS*			
		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	+ 43	- 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)

END / *EINDE*