GAUTENG DEPARTMENT OF EDUCATION

SENIOR CERTIFICATE EXAMINATION

TECHNIKA (MECHANICAL) HG

TIME: 3 hours

MARKS: 300

REQUIREMENTS:

- Calculator, drawing instruments and information pamphlet

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 10 – 13) are provided at the end of the paper.

QUESTION 1

1.1 Draw neat sketches of THREE basic surface-finish symbols and state the meaning of each. (9)

1.2 Define **power**. (2)

1.3 Use the table of primary fits in the information pamphlet and state the following:

1.3.1 The limits for a **45H9 - d10** hole-shaft combination (4)

1.3.2 The type of fit (2)

1.4 What is the cause of belt slippage? (5)

1.5 A vehicle with a mass of 200 kg moves at a velocity of 21 $m.s^{-1}$ on a horizontal plane. The brakes are applied and the vehicle comes to rest over a distance of 60 m. Calculate the

1.5.1 deceleration. (4)

1.5.2 braking force. (3)

1.5.3 time taken to bring the vehicle to rest. (4)

1.6 One hundred and six (106) teeth must be milled on a spur gear. The dividing head ratio is 40:1.

1.6.1 Calculate the indexing required. (Choose 110 divisions.) (2)

1.6.2 Calculate the change wheels required. (5)

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

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

1.7 State the **law of Boyle**. (4)
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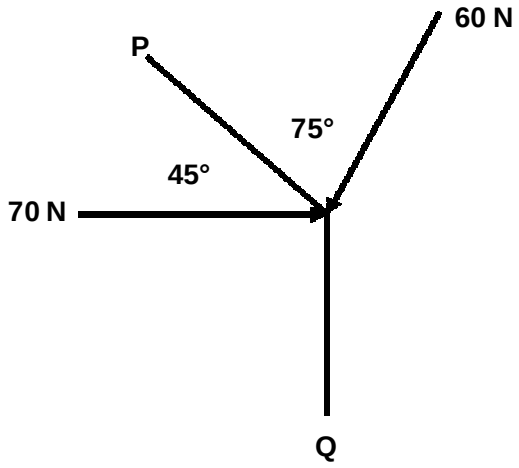
QUESTION 2

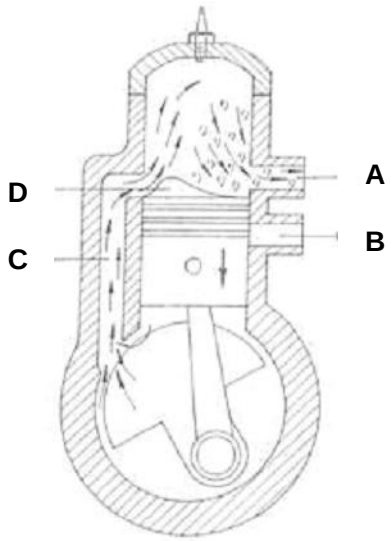
2.1 Determine **graphically** the magnitude of the two forces **P** and **Q**. The system of forces is in equilibrium.



(10)

2.2 Define a **vector**. (2)

2.3 The figure below shows a section of an internal combustion engine. Study the sketch and answer the following questions.



2.3.1 Name the type of internal combustion engine. (2)

2.3.2 Draw a volume-pressure diagram for this engine. Add the necessary labels. (6)

2.4 Define each of the following:

2.4.1 Indicated power (4)

2.4.2 Mean effective pressure (3)

2.5 An engine develops a torque of 250 Nm at 2 800 revolutions per minute. Calculate the brake power in kW. (4)

2.6 Describe how the following gear ratios are obtained by means of a single epicyclic gear train:

2.6.1 Reduction gear ratio (4)

2.6.2 Overdrive gear ratio (4)

2.7 Why is industrial housekeeping very important? (5)

2.8 Briefly describe the chemical combustion process of petrol in the presence of sufficient oxygen. Name the products of this combustion. (6)

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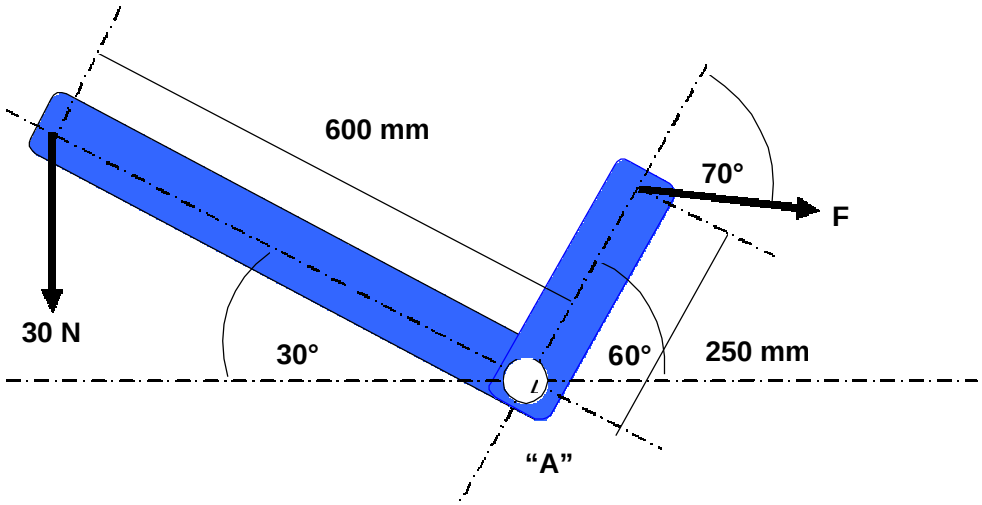
QUESTION 3

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



(16)

3.2 Describe Young's modulus of elasticity (E). (4)

3.3 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)

3.4 A brass bar 10 mm in diameter is tightly secured at the top end and hangs vertically. A mass **M** is clamped on the bottom end so that the effective length of the bar is 2 m. Calculate the magnitude of the mass if it extends with 0,124 mm. Take **E** for brass as 70 GPa. (11)

3.5 Describe the colour penetrating test used to test steel for defects. (7)

3.6 Define **ISOTERMAL compression of gasses**. (4)

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QUESTION 4

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

4.2 Prove that 2 radians are equal to 104,6º. (4)

4.3 The mass of a flywheel is 78 kg and the radius of inertia is 302 mm. The flywheel is accelerated from 420 r.p.m. to 1 120 r.p.m. in 12 seconds. Calculate the

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

4.3.2 accelerating torque. (4)

4.3.3 moment of inertia. (4)

4.3.4 kinetic energy at 1 120 r.p.m. (5)

4.4 A truck with a mass of 3 000 kg is accelerated uniformly from rest to 6 m.s^{-1} over a distance of 600 m up an incline of 1:30. The resistance against motion is 200 N. Calculate the

4.4.1 component of gravitational force parallel to the plane. (4)

4.4.2 acceleration. (4)

4.4.3 effective accelerating (unbalanced) force. (3)

4.4.4 total force on the truck. (4)

4.5 Sketch a complete iron-carbon equilibrium diagram for steel types. Indicate the temperature between 0º C and 1000º C , and the carbon content between 0% and 1,4%. (10)
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QUESTION 5

5.1 Define the following concepts:

5.1.1 Potential energy (4)

5.1.2 Kinetic energy (4)

5.2 The following data are provided for a six-cylinder four-stroke internal combustion engine:

Cylinder diameter	96 mm
Stroke length	110 mm
Mean effective pressure on piston	980 kPa
Revolutions per minute	3 500 r.p.m.
Effective brake arm length	1 200 mm
Reading on scale	16 kg

Calculate the following:

5.2.1 The indicated power in kW (7)

5.2.2 The work done during ONE power stroke if the piston moves from the TDC to the BDC. (3)

5.2.3 The brake power in kW (4)

5.2.4 The mechanical efficiency of the engine (3)

5.3 A force of 200 N is applied to the end of a spanner. The perpendicular distance between the working line of the force and the centre line of the nut is 0,5 m. Calculate the

5.3.1 torque. (2)

5.3.2 work done when the nut is turned through an angle of 30° while the torque remains constant. (5)

5.4 A power of 9 kW is transmitted from a driver pulley with a diameter of 0,6 m rotating at 900 r/min, to a driven pulley rotating at 550 r/min. The tension ratio of the tight side to the slack side is 3:1. The allowable tension in the belt is 4 N per mm belt width. Calculate the

5.4.1 diameter of the driven pulley. (4)

5.4.2 tension forces T_1 and T_2. (5)

5.4.3 velocity ratio. (3)

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

5.6 Name FOUR characteristics of a good industrial leader. (4)
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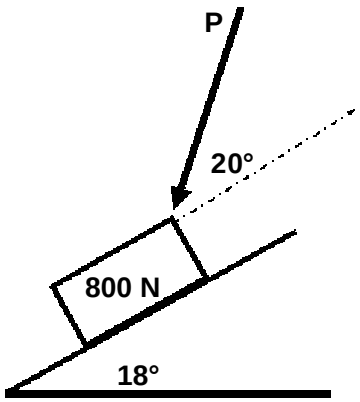
QUESTION 6

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

6.2 A body with a mass of 800 N is placed on an inclined plane making an angle of 18º with the horizontal. The coefficient of friction is 0,4. Calculate the magnitude of the smallest force **P** that will push the object down the incline.



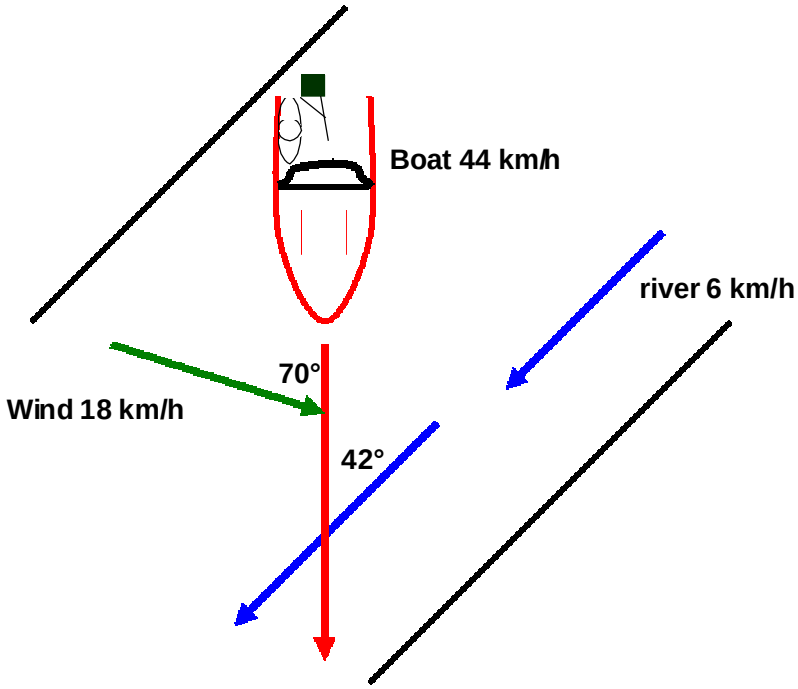
(8)

6.3 Name the factors that have an influence on the structural change during welding. (5)

6.4 Describe the Rockwell hardness test. (8)

6.5 The use of alcohol and drugs has detrimental effects on society and the work environment. State FOUR of these effects. (4)

6.6 Calculate the resultant velocity of the boat as shown in the sketch.



(16)
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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 / 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:

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

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 = $\frac{pD^2}{4}$ or / *of* $p\ r^2$

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 *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*