Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2012

MECHANICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

* M C H T D M *

This question paper consists of 23 pages, including an answer sheet and formula-sheets.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read all the questions carefully.
3. Number the questions correctly according to the numbering system used in this question paper.
4. Write neatly and legibly.
5. Show ALL the calculations and units.
6. Candidates are allowed to use non-programmable, scientific calculators and drawing/mathematical instruments.
7. The value of gravitational acceleration constant should be taken as 10 m/s^2.
8. Use the criteria below to assist you in managing your time:

Question	Assessment Standards	Content covered	Marks	Time
1	1 – 9	Multiple-choice questions	20	18 minutes
2	6 and 8	Forces, Systems and Control	50	45 minutes
3	2	Tools/equipment	20	18 minutes
4	3	Materials	20	18 minutes
5	1, 4 and 5	Safety, Terminology, Joining methods	50	45 minutes
6	7 and 9	Turbines and maintenance	40	36 minutes
		TOTAL	**200**	**180 minutes**

QUESTION 1 is to be answered on this answer sheet.

VRAAG 1 moet op hierdie antwoordblad beantwoord word.

NAME/NAAM: _____

ANSWER SHEET/ANTWOORDBLAD		
QUESTION/VRAAG	**1**	**(MULTIPLE CHOICE QUESTIONS)/ (MEERVOUDIGEKEUSE-VRAE)**

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D
1.11	A	B	C	D
1.12	A	B	C	D
1.13	A	B	C	D
1.14	A	B	C	D
1.15	A	B	C	D
1.16	A	B	C	D
1.17	A	B	C	D
1.18	A	B	C	D
1.19	A	B	C	D
1.20	A	B	C	D

TOTAL	

Tear off this page and submit with answer book.

SECTION A:

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 1 – 9)

Various options are provided as possible answers to the following questions. Choose the answer and make a cross (X) in the appropriate block on the ANSWER SHEET, for example

1.21	A	B	C	D

1.1 Which ONE of the following statements is a basic rule for the safe handling of a surface grinder?

A. Make sure that you know how to stop the machine quickly.
B. Make sure that the grinding wheel touches the cutting fluid while setting-up takes place.
C. Make sure that the grinding process commences as soon as the machine is switched on.
D. No eye protection is needed due to the safety shields right around the machine. (1)

1.2 Which safety regulation is applicable on the hydraulic press in terms of the Occupational Health and Safety act?

A. Do not use gloves when handling sheets of metal that have been cut.
B. Safe pressure may be exceeded for short periods.
C. Use the cables to keep the platform square while presswork is being done.
D. Place the work piece in suitable jig-apparatus before commencing with press work. (1)

1.3 Which of the following apparatus is used to test the hardness of material?

A. Torsion tester
B. Vickers tester
C. Stress tester
D. Pull tester (1)

1.4 Identify the advanced engineer's apparatus that is shown below.

FIGURE 1.4

A. Gas analyser
B. Spring tester
C. MIG welding machine
D. Compression tester (1)

1.5 Aluminium is about ... as DENSE as steel, copper and most other metals.

A. one third
B. one six
C. one quarter
D. None of the above-mentioned (1)

1.6 What is the common use of teflon?

A. Castings
B. Pipes
C. Orthopaedic appliances
D. Covering of work-surfaces (1)

1.7 Identify the milling cutter shown below.

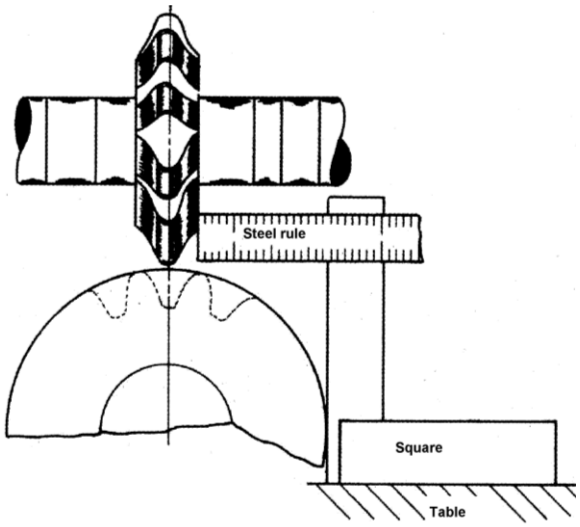


FIGURE 1.7

A. Involute cutter
B. Side- and face cutter
C. Helical cutter
D. Groove cutter (1)

1.8 What type of cutting fluid will you use when drilling aluminium?

A. Normal lubricating oil
B. Soluble oil
C. Tap water
D. Paraffin (1)

1.9 What is the definition of *porosity*?

A. Holes that form during the welding process because of trapped gases.
B. Small bubbles appearing in the welded material.
C. It appears at the end of the welding.
D. Non-metal solids trapped in the welding joint. (1)

1.10 What do you understand under the term nick break test?

A. Break the welding open to test for internal defects.
B. Break the welding open to test for external defects.
C. Test the toughness of the welding.
D. Test the high frequency sound effect of the welding joint. (1)

1.11 What will the stress be in a 15 mm square bar if the load of 10 kN is applied on the square bar?

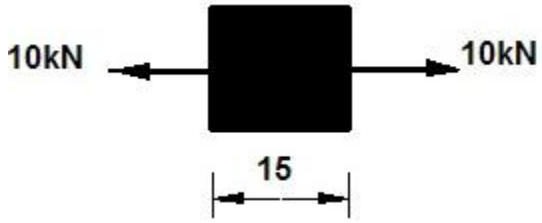


FIGURE 1.11

A. 444,44 MPa
B. 2250 kPa
C. 88,89 kPa
D. 44,44 MPa (1)

1.12 In the stress/strain diagram Point E represents:

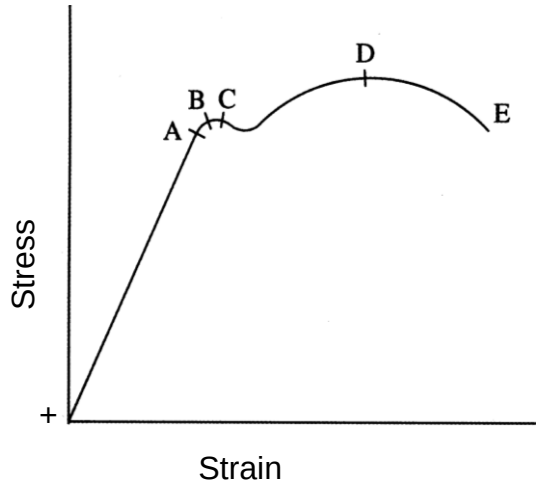


FIGURE 1.12

A. Maximum stress
B. Limit of proportionality
C. Break stress
D. Elastic limit (1)

1.13 When changing a chain the following must be observed:

A. The tension is set correctly.
B. The sprockets are aligned.
C. The chain is the correct size.
D. All the above mentioned. (1)

1.14 When changing a motor car's clutch you buy a clutch set consisting of which parts?

A. Clutch plate, pressure plate and thrust bearing
B. Clutch plate and pressure plate
C. Clutch plate and thrust bearing
D. Clutch plate, flywheel, pressure plate and thrust bearing (1)

1.15 Calculate the gear ratio of the gear train shown below. The speed of the drive gear is 840 r/min.

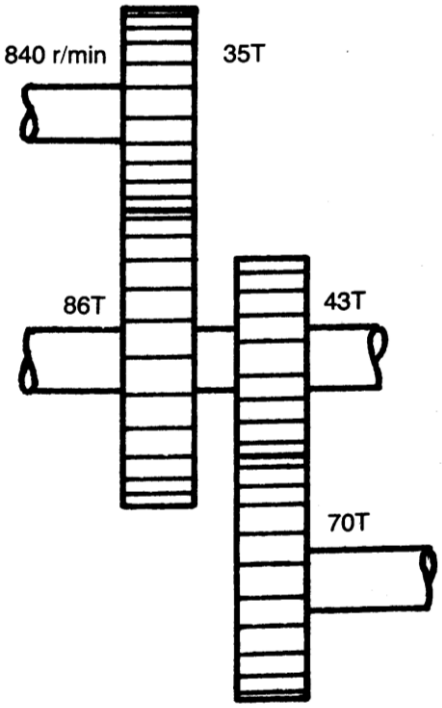


FIGURE 1.13

A. 1 : 1
B. 4 : 1
C. 1 : 4
D. 2 : 1 (1)

1.16 What will the lead of an acme screw thread be, if the pitch is 3 mm and it is a three start thread?

A. 9 mm
B. 6 mm
C. 3 mm
D. 12 mm (1)

1.17 Which of the statements below represents the operation of a turbocharger?

A. Turbochargers are driven by gears.
B. Turbochargers are driven by pulleys.
C. Turbochargers are driven by exhaust gases.
D. Turbochargers are driven by inlet gases. (1)

1.18 What do you understand with the term DUMP VALVE as used in turbo chargers terminology?

A. Closed lubricating system of the turbo
B. Removing of outlet gases from the inlet system
C. Mechanical control system of the turbo wheel
D. Electronically control system of the fuel injectors (1)

1.19 Which of the following advantages is NOT applicable when referring to a Helical milling cutters?

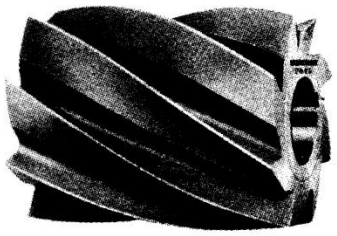


FIGURE 1.19

A. Helical cutters use less power.
B. There is less vibration on the machine.
C. Less side thrust on the arbour bearings.
D. Deeper cuts can be taken. (1)

1.20 Which of the following instructions DO NOT form part of the basic principles when programming a CNC lathe?

A. Tool selection
B. Cutting speed selection
C. Application of a coolant
D. Guidance to safety precautions (1)

[20]

QUESTION 2 FORCES AND SYSTEMS AND CONTROL

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 6 AND 8)

2.1 The grade 12 Mechanical Technology learners perform a tensile test on a 24 mm diameter mild steel bar. If a load of 60 kN is applied to the steel bar the elongation is 0,22 mm. The original length is 212 mm.

FIGURE 2.1

Calculate the following:

2.1.1 Stress in the mild steel bar (5)

2.1.2 Strain in the mild steel bar (3)

2.1.3 Young's modulus (3)

2.2 A round hole has to be punched into a 14 mm thick steel plate. The punching force is 380 kN and the allowable shearing stress in the plate may not exceed 420 MPa.

Calculate the maximum size hole that can be punched in millimetres. (6)

2.3 Define the term Hook's law. (2)

2.4 You are an engineer at a local design company. A client requests you to analyse a flat belt drive.

The client gave the following specifications:
Belt width is 200 mm and is 5 mm thick.
Drive pulley diameter is 1 m and rotates at 200 r/min.
Safe work stress in the belt material is 300 kPa.
Stress on the tight side is 2,5 times that of the stress on the slack side.

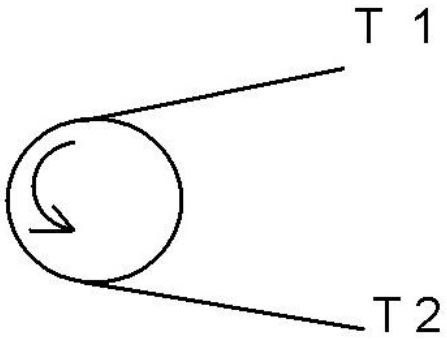


FIGURE 2.4

CALCULATE the power that will be transmitted in kilowatt. (11)

2.5 In the figure below a load of 800 N is applied on piston B of a hydraulic press. Piston B moves upwards with 10 mm. The cross sectional area of piston A is 0,015 m^2 and that of piston B is 0,16 m^2.

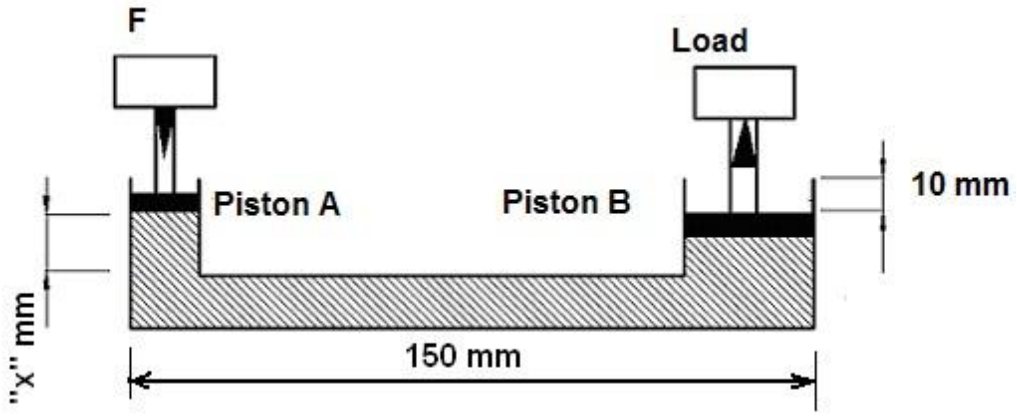


FIGURE 2.5

Calculate:

2.5.1 The applied force (F) on piston A. (3)

2.5.2 The distance "x" that piston A will move in millimetres. (3)

2.5.3 If the length of the hydraulic press doubles, what effect will it have on the distance "x"? (2)

2.6 The mechanical advantage of a hoisting appliance (wheel and axle) used in the local harbour, is 4. A load of 1,57 kN is lifted when a force "F" is applied. The diameters of the pulleys are respectively 210 mm (D), 160 mm (d2) and 130 mm (d1).

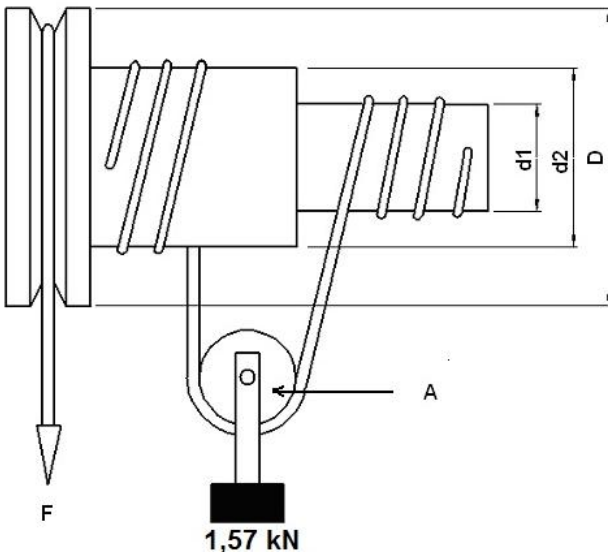


FIGURE 2.6

Calculate:

2.6.1 The magnitude of the applied force "F" (2)

2.6.2 The velocity ratio (2)

2.7 A feeding mechanism that releases the amount of food broke down. A two start square screw thread with an outside diameter of 55 mm and a pitch of 10 mm is in use at the moment.

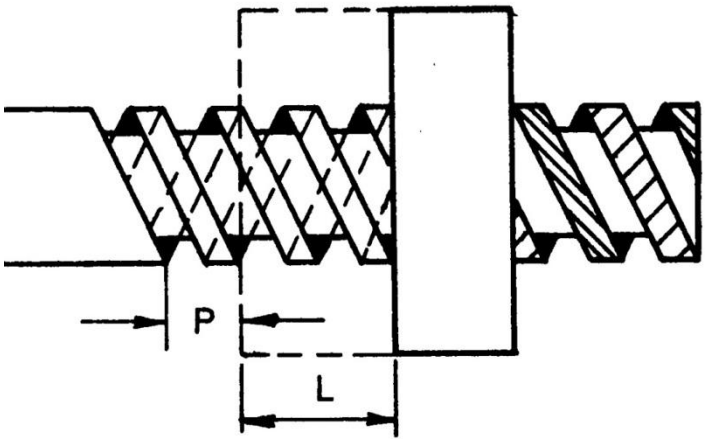


FIGURE 2.7

Calculate:

2.7.1 The farmer wants more adjustment with the same amount of turns in order to regulate the feeding mechanism. Advise the farmer what to do. Motivate your answer. (2)

2.7.2 CALCULATE the helix angle of the screw thread. (3)

2.8 A single friction clutch plate with an effective diameter of 0,16 m is used to transmit power of 43,982 kW at 3000 r.p.m. in a motor/generator combination. The clutch plate has friction material on both sides. The friction co-efficient is 0,35. The total applied force on the pressure plate is 2,5 kN.

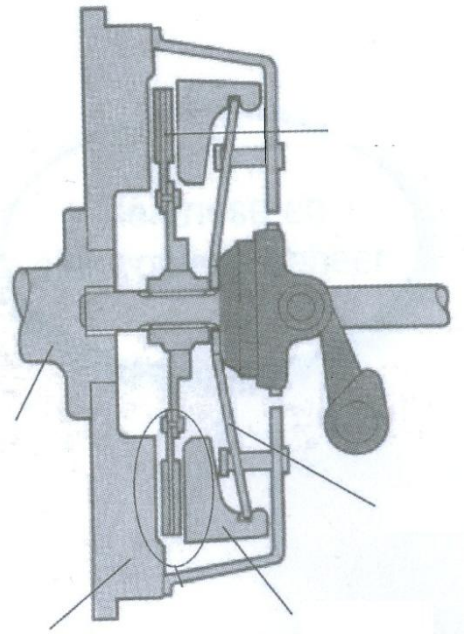


FIGURE 2.8

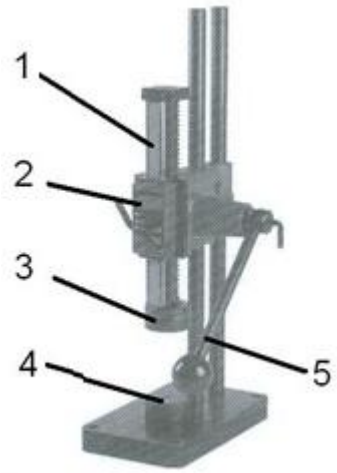
CALCULATE the maximum torque that can be transmitted. (3)

[50]

QUESTION 3 TOOLS AND EQUIPMENT

(LEARNING OUTCOME 3: ASSESSMENT STANDARD 2)

3.1 The sketch below shows a spring compression tester. Label the sketch numbered 1 to 5.



(5)

FIGURE 3.1

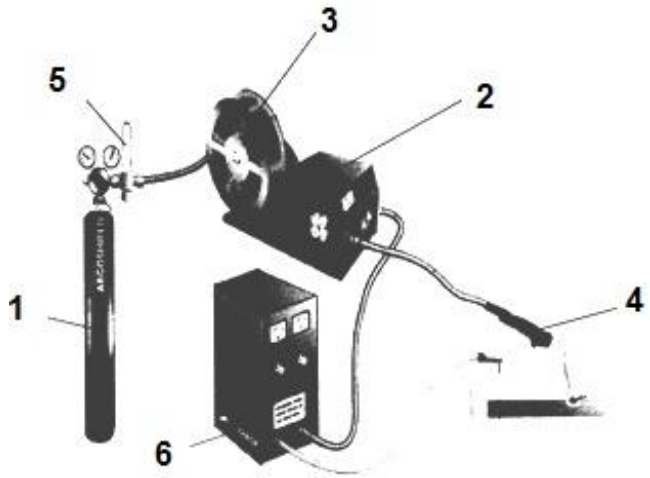
3.2 Describe the functions of:

3.2.1 Gas analyser (1)

3.2.2 Pressure tester (1)

3.2.3 Cylinder leakage tester (1)

3.3 FIGURE 3.3 shows a MIG-welding machine. Label the sketch numbered 1 to 6.



(6)

FIGURE 3.3

3.4 How is the pressure leak on an engine identified during a cylinder leakage test? (3)

3.5 Which THREE points should you keep in mind when working with a multimeter? (3)

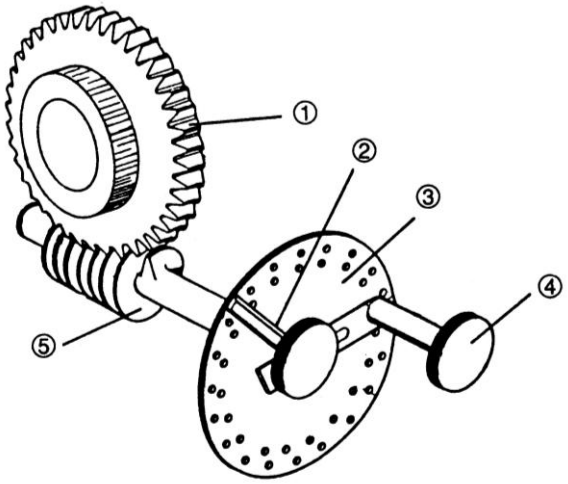
[20]

QUESTION 4 MATERIALS

(LEARNING OUTCOME 3: ASSESSMENT STANDARD 3)

4.1 When two or more metallic elements are melted together, they form a mixture called an alloy. Name FIVE reasons for creating alloys. (5)

4.2 The worm wheel of the dividing head is made of brass while the worm is made of stainless steel. Answer the questions that follow:



① 40-tooth wormwheel
② Sector arm
③ Index plate
④ Crankpin
⑤ Single-start worm

FIGURE 4.2

4.2.1 List the elements of brass. (2)

4.2.2 Give TWO reasons why brass is used for the manufacturing of the worm wheel. (2)

4.3 Tabulate ONE property and use of the following non-ferrous metal.

4.3.1 Aluminium (Al) (2)

4.3.2 Copper (Cu) (2)

4.3.3 Lead (Pb) (2)

4.4 Polyvinyl chloride ("PVC") is created from two natural materials. Name the TWO elements. (2)

4.5 Teflon is used in the engineering because of certain properties it POSSESSES. Name THREE of these properties. (3)

[20]

QUESTION 5 SAFETY, TERMINOLOGY AND JOINING METHODS

(LEARNING OUTCOME 3: ASSESSMENT STANDARDS 1, 4 AND 5)

5.1 The gas in the cylinder of a welding plant is highly inflammable. You as an apprentice together with a qualified person are busy working on a machine. Which safety regulations are applicable during the use of the oxy-acetylene apparatus? Name THREE safety regulations. (3)

5.2 A tensile test is a destructive test carried out to determine maximum tensile stress and elongation. Name THREE safety precautions to consider for accurate and safe testing. (3)

5.3 You need to perform a gas analysing test for your practical mark. Name FOUR safety precautions to be observed before and while the test is being done. (4)

5.4 The dividing head is a supplementary component to the milling machine and has a ratio of 40:1. Name THREE functions of the dividing head. (3)

5.5 Calculate the angle indexing required to produce an angle of 16°30'. (3)

5.6 Name THREE methods of indexing when using the milling machine. (3)

5.7 Mr Wanga needs to cut a spur gear compromising 40 teeth and a module of 2,0 mm using the milling machine. Calculate:

5.7.1 The addendum (2)

5.7.2 The dedendum (2)

5.7.3 The cutting depth (2)

5.7.4 The circular pitch (2)

5.7.5 The clearance (2)

5.7.6 The pitch circle diameter (PCD) (2)

5.8 Name THREE advantages gained when a smaller diameter cutter is chosen to perform a specific task. (3)

5.9 Mike must set up a milling machine and needs the FEED SPEED in millimetre per minute of a 65 mm diameter gear cutter with 16 teeth, operating at a cutting speed of 28 meter per minute and a feed of 0,06 mm per tooth. CALCULATE the feed speed in millimetre per minute for Mike. (6)

5.10 5.10.1 FIGURE A shows an incomplete penetration of a welding joint. Identify TWO causes and suggest ONE correction/remedy.

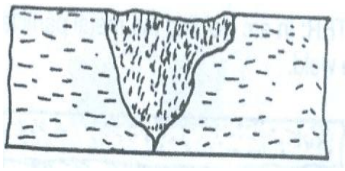


FIGURE A (3)

5.10.2 FIGURE B shows porous penetration of a welding joint. Identify TWO causes and suggest ONE correction/remedy.

FIGURE B (3)

5.11 Welded joint testing is done to check the quality of the joint more thoroughly. The nick break test is one such method. Describe, STEP-BY-STEP, how this test will be performed. (4)

[50]

QUESTION 6 TURBINE AND MAINTENANCE

(LEARNING OUTCOME 3: ASSESSMENT STANDARD 7 AND 9)

6.1 The water pump on Mr Mbuli's vehicle must be replaced due to a strange noise while he is driving. Name FOUR possible causes of bearing failure. (4)

6.2 A V-belt is used to drive the water pump and alternator of a motor vehicle.

6.2.1 Name THREE advantages when using a v-belt. (3)

6.2.2 Name THREE reasons why v-belts will slip. (3)

6.3 You are changing your vehicle's engine oil. Your youngest brother wants to know what the letters and numbers denote in SAE 20W50 on the oil can. Answer the questions that follow:

6.3.1 Describe, STEP-BY-STEP, the above mentioned procedure when changing your vehicle's engine oil. (8)

6.3.2 Explain the following:

(a) SAE (1)

(b) 20 (1)

(c) W (1)

(d) `50 (1)

6.4 Milling machines, lathes and even surface grinders use cutting fluid during the machining process. Name FIVE advantages of using cutting fluid. (5)

6.5 Identify the THREE blowers as shown below in the figures. (3)

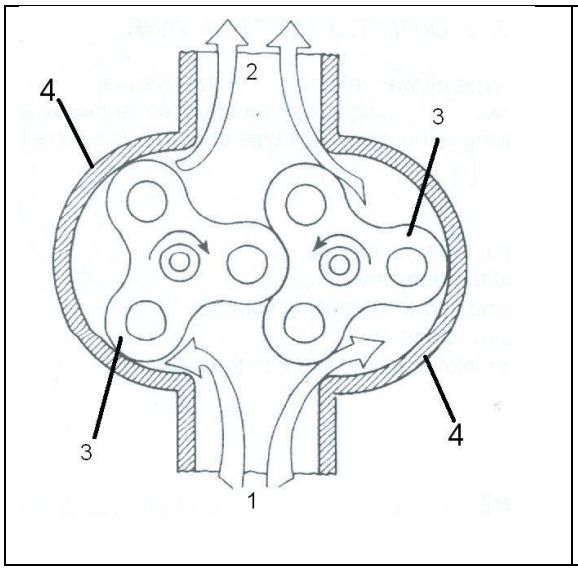


FIGURE 6.5.1

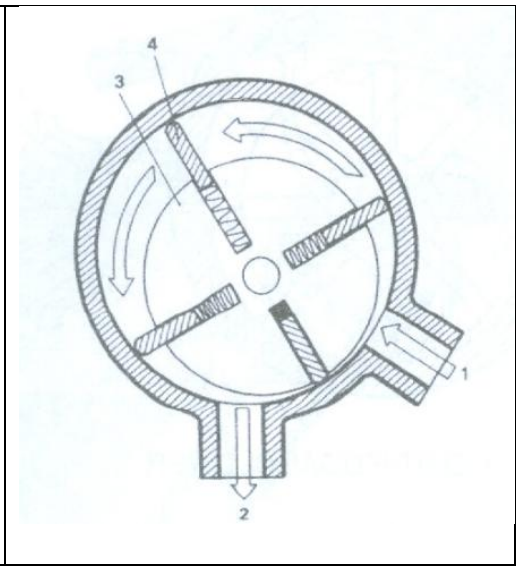


FIGURE 6.5.2

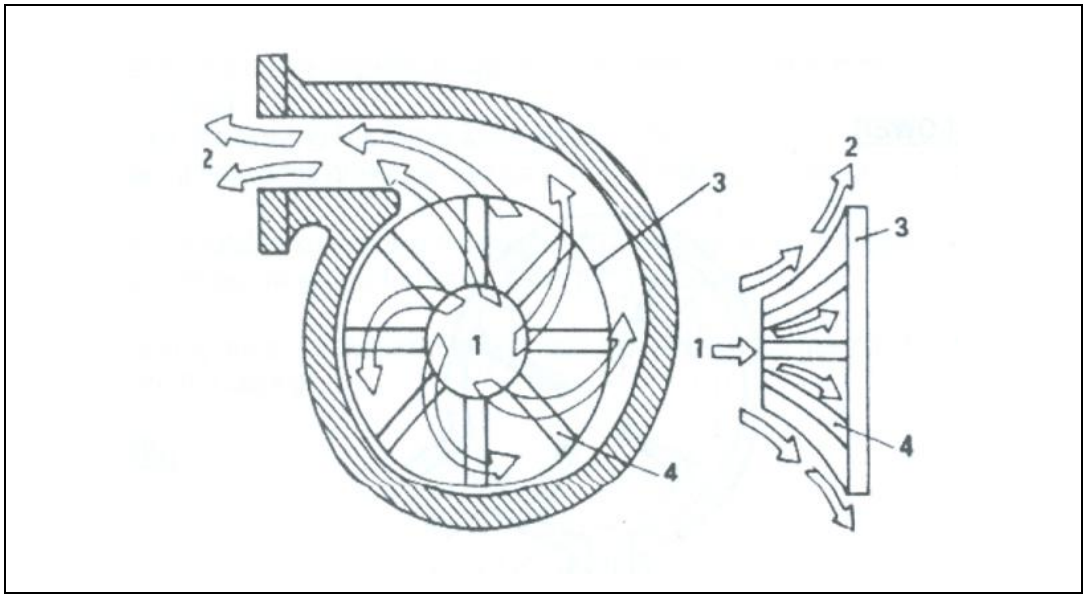


FIGURE 6.5.3

6.6 Label the parts of FIGURE 6.5.1 numbered 1 to 4. (4)

6.7 Which of the blowers can be used as both a supercharger and turbocharger? (1)

6.8 How do turbochargers differ from superchargers? (2)

6.9 Name THREE disadvantages of the turbocharger compared to that of superchargers. (3)

[40]

TOTAL: 200

MECHANICAL TECHNOLOGY: GRADE 12-FORMULE SHEET

1. BELT DRIVES

1.1 Belt speed = $\frac{\pi DN}{60}$

1.2 Belt speed = $\frac{\pi\ D+t\ N}{60}$ (t = belt thickness)

1.3 Belt mass/kilogram = $\text{Area} \times \text{length} \times \text{density}$ (A = thickness × width)

1.4 Speed ratio = $\frac{\text{Dia.of driven pulley}}{\text{Dia.of driver pulley}}$

1.5 Output speed = $\frac{drive\ pulley}{driven\ pulley} \times \frac{drive\ pulley}{driven\ pulley} \times input\ speed$

1.6 Open-belt length = $\frac{\pi\ D+d}{2} + \frac{(D-d)^2}{4c} + 2c$

1.7 Crossed-belt length = $\frac{\pi(D+d)}{2} + \frac{(D+d)^2}{4c} + 2c$

1.8 Power (P) = $\frac{2\pi NT}{60}$

1.9 Ratio of tight side to slack side = $\frac{T_1}{T_2}$

1.10 Power (P) = $\frac{(T_1-T_2)\pi DN}{60}$ where T_1 = force in the tight side

1.11 Width = $\frac{T_1}{Permissible\ tensile\ force}$

2. FRICTION CLUTCHES

2.1 Torque (T) = μWnR

μ = coefficient of friction
W = total force
n = number of friction surfaces
R = effective radius

2.2 Power (P) = $\frac{2\pi NT}{60}$

3. STRESS AND STRAIN

3.1 Stress = $\frac{Force}{Area}$ or ($\sigma = \frac{F}{A}$)

3.2 Strain (ϵ) = $\frac{change\ in\ length\ (\Delta L)}{original\ length\ (L)}$

3.3 Young's modulus (E) = $\frac{stress}{strain}$ or ($\frac{\sigma}{\epsilon}$)

3.4 $A_{shaft} = \frac{\pi D^2}{4}$

3.5 $A_{pipe} = \frac{\pi(D^2 - d^2)}{4}$

4. HYDRAULICS

4.1 Pressure (P) = $\frac{Force\ (F)}{Area\ (A)}$

4.2 Volume = Cross-sectional area x stroke length (l or s)

4.3 Volume liquid displaced by plunger = volume liquid displaced by ram

4.4 Volume = Area $\times$ $stroke\ lenght$

5. WHEEL AND AXLE

5.1 Velocity ratio (VR) = $\frac{effort\ distance}{load\ distance} = \frac{2D}{d_2 - d_1}$

5.2 Mechanical advantage (MA) = $\frac{Load\ (W)}{Effort(F)}$

5.3 Mechanical efficiency (η_{mech}) = $\frac{MA}{VR} \times 100\%$

6. LEVERS

6.1 Mechanical advantage (MA) = $\frac{Load\ (W)}{Effort(F)}$

6.2 Input movement (IM) = $Effort \times distance\ moved\ by\ effort$

6.3 Output movement (OM) = $load \times distance\ moved\ by\ load$

6.4 Velocity ratio (VR) = $\frac{\text{Input movement}}{\text{Output movement}}$

7. GEAR DRIVES
SPUR GEAR

7.1 Power (P) = $\frac{2\pi NT}{60}$

7.2 Gear ratio = $\frac{product\ of\ number\ of\ teeth\ on\ driven\ gears}{product\ of\ number\ of\ teeth\ on\ driving\ gears}$

7.3 $$\frac{N_{input}}{N_{output}} = \frac{product\ of\ number\ of\ teeth\ on\ driven\ gears}{product\ of\ number\ of\ teeth\ on\ driving\ gears}$$

7.4 Torque = $force \times raduis$

7.5 Torque transmitted= $gear\ ratio \times input\ torque$

7.6 Module (m) = $\frac{pitch\ circle\ diameter\ (PCD)}{number\ of\ teeth\ (T)}$

7.7 Pitch circle diameter (PCD) = $\frac{circular\ pitch\ \ CP\ \times number\ of\ teeth\ (T)}{\pi}$ or PCD = T× m

7.8 Outside diameter (OD) = $PCD + 2\ module$ or OD = m(T + 2)

7.9 Addendum (a) = module (m)

7.10 Dedendum (b) = 1,157 m or Dedendum (b) = 1,25 m

7.11 Cutting depth (h) = 2,157 m or Cutting depth (h) = 2,25 m

7.12 Clearance (c) = 0,157 m or Clearance (c) = 0,25 m

7.13 Circular pitch = $\pi \times m$

7.14 Work depth = $2 \times add$ or work depth = $2 \times m$

8. HELICAL GEAR

8.1 Pitch circle diameter: PCD = T× m_r

8.2 Addendum (a) = module (m_n)

8.3 Dedendum = 1,157 m_n

8.4 Clearance = 0,157 m_n

8.5 Outside diameter (OD) = PC$D + 2\ addendum$

8.6 T = $\frac{SSD}{m_r}$

8.7 (Normal module) m_n = (module real) m_r COS θ

8.8 Number of teeth marked on milling cutter: Nr =$\frac{T}{(COS\theta)^3}$

8.9 Helix angle : θ
TAN $\theta = \frac{\pi \times PCD}{Lead\ of\ work\ piece}$

8.10 Lead of work piece = $\frac{\pi \times PCD}{TAN\theta}$

8.11 Lead of milling machine = dividing head ratio × lead screw pitch

8.12 Change gears:$\frac{Dr}{Dn} = \frac{lead\ of\ machine}{slead\ of\ work\ piece\ (gear)}$

8.13 Circle pitch = $\pi \times m_n$

8.14 The milling machine has a table lead screw with a 6mm pitch unless stated otherwise.

9. SCREW THREADS

9.1 Pitch diameter (D_e) = OD – (0,5 x pitch)

9.2 Lead = pitch ×number of starts

9.3 Helix angle : θ
TAN $\theta = \frac{lead}{\pi \times D_e}$

9.4 Leading angle = 90° - (helix angle + clearance angle)

9.5 Following = 90° + (helix angle – clearance angle)

9.6 Clearance angle = 3° unless stated differently

10. DIVIDING HEAD TABLE FOR THE MILLING MACHINE

HOLE CIRCLES											
Side 1	24	25	28	30	34	37	38	39	41	42	43
Side 2	46	47	49	51	53	54	57	58	59	62	66

STANDARD CHANGE GEARS										
24 x 2	28	32	40	44	48	56	64	72	86	100

10.1 Simple indexing = $\frac{40}{n}$ (where n = number of divisions)

10.2 Change gears: $\frac{Dr}{Dn} = \frac{Dr}{Dv} = (A - n) \times \frac{40}{A}$ or $\frac{Dr}{Dv} = \frac{(A-n)}{A} \times \frac{40}{1}$

10.3 Angle ind = $\frac{angle\ in\ minutes}{540'}$

11. CALCULATIONS OF FEED

11.1 Feed (f) = $f_1 \text{x} T \text{x} N$

Where f = feed per millimetre per minute
f_1 = feed per tooth in millimetres
T = number of teeth in cutter
N = number of revolutions of cutter per minute

11.2 Cutting speed (V) = π x D x N
Where D = diameter of the cutter in metres