basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2011

MARKS: 200

TIME: 3 hours

This question paper consists of 19 pages, a 5-page formula sheet and 1 answer sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK and the ANSWER SHEET.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Answer the questions in QUESTION 1 on the attached ANSWER SHEET. Place the completed ANSWER SHEET in the ANSWER BOOK.
5. Number the answers correctly according to the numbering system used in this question paper.
6. Start EACH question on a NEW page.
7. Show ALL calculations and units. Round off final answers to TWO decimal places.
8. Candidates may use non-programmable scientific calculators and drawing instruments.
9. The value of gravitational force should be taken as 10 m/s^2.
10. All dimensions are in millimetres, unless stated otherwise in the question.
11. Write neatly and legibly.
12. Use the criteria below to assist you in managing your time.

QUESTION	ASSESSMENT STANDARDS	CONTENT	MARKS	TIME
1	1–9	Multiple-choice Questions	20	18 minutes
2	2	Tools and Equipment	20	18 minutes
3	3	Materials	20	18 minutes
4	1, 4 and 5	Safety, Terminology and Joining Methods	50	45 minutes
5	7 and 9	Maintenance and Turbines	40	36 minutes
6	6 and 8	Forces and Systems and Control	50	45 minutes
		TOTAL	**200**	**180 minutes**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and make a cross (X) in the block (A–D) next to the question number (1.1–1.20) on the attached ANSWER SHEET.

EXAMPLE:

1.21	A	B	C	D

1.1 Which ONE of the following safety measures applies to a tensile tester?

A Apply excessive pressure.
B Use a hammer to remove the test piece.
C Lower the fluid level.
D The work piece should be well secured. (1)

1.2 Which ONE of the following safety procedures relates to the bearing and gear puller?

A Make sure that the legs of the puller are straight.
B Make sure that two of the three legs are well secured when pulling.
C Oil the contact surfaces.
D Use a hammer to assist with the removal of the components. (1)

1.3 What is the function of a gas analyser?

A To analyse inlet gases
B To analyse exhaust gases
C To analyse smoke
D To analyse the air-fuel mixture (1)

1.4 What is the function of an inert gas?

A It keeps the weld cool.
B It produces heat.
C It allows smooth transfer of metal from the welding wire to the molten weld pool.
D It shields the arc and molten weld pool from atmospheric gases. (1)

1.5 Raj has to soft solder a bronze pipe fitting. What step of the soldering process is shown in FIGURE 1.1?

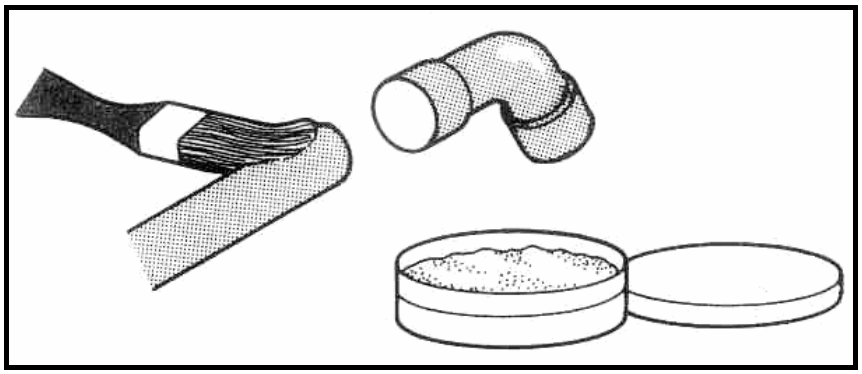

FIGURE 1.1

A Clean the surface to be joined with steel wool.
B Heat the joint and apply solder to the joint.
C Allow the joint to cool.
D Apply cleaning agent to the surface. (1)

1.6 What are *thermosetting plastics*?

A Materials that form a rigid shape under pressure or heat
B Materials that can be stretched but return to their original shape
C Materials that cannot be reshaped by reheating
D Materials that soften when heated and harden when cooled (1)

1.7 Identify the type of milling cutter shown in FIGURE 1.2.

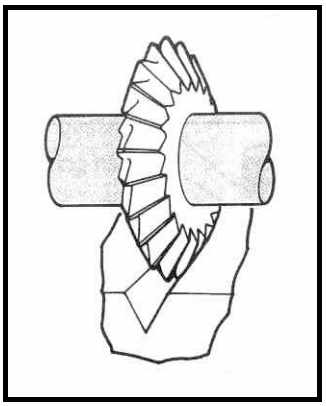

FIGURE 1.2

A Convex cutter
B Single corner-rounding cutter
C Cylindrical cutter
D Equal-angle cutter (1)

1.8 Which lathe operation is shown in FIGURE 1.3?

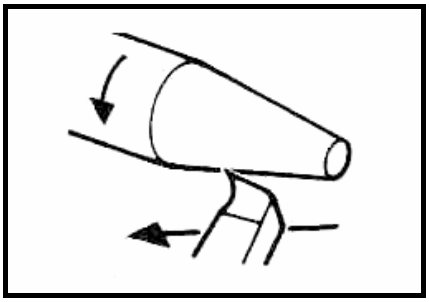

FIGURE 1.3

A Turning a bar
B Turning a taper
C Thread cutting
D Boring (1)

1.9 What is the advantage of up-cut milling?

A The strain on the arbor and cutter is less.
B The finish obtained is finer.
C More vibration is expressed.
D There is a tendency of the cutter to lift the work piece. (1)

1.10 What is the reason for using a free-bend test?

A To determine the internal quality of the weld
B To check the size of the weld
C To detect surface flaws
D To measure the ductility of the weld deposit (1)

1.11 Which ONE of the following is an advantage of a helical cutter?

A It is easy to manufacture.
B It does not require cooling.
C The vibration on the machine is less.
D It does not require sharpening. (1)

1.12 The unit for compressive stress is …

A newton.
B metre.
C pascal.
D watt. (1)

1.13 What is *Hooke's law*?

A The measurement of extension or contraction of a bar when an external load is applied
B The stress value required to produce unit strain in a tensile specimen of a particular material
C Strain is directly proportional to the stress it causes, provided the limit of proportionality is not exceeded
D A measurement of the deformation produced by the application of the external forces (1)

1.14 What is the function of the self-aligning ball bearing shown in FIGURE 1.4?

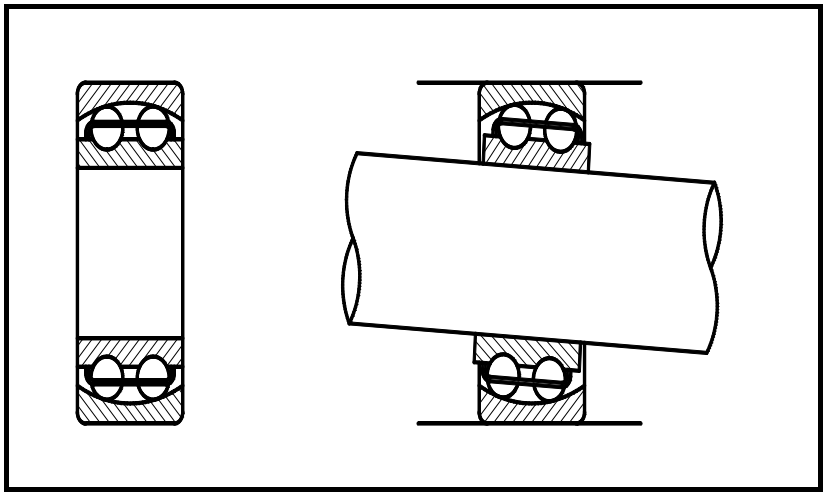

FIGURE 1.4

A For supporting light radial loads
B For allowing misalignment between inner and outer grooves
C For supporting high-pressure loads
D For carrying a combination of radial and axial thrust loads (1)

1.15 Which ONE of the following steps should be followed when meshing a rolling chain and a sprocket wheel as shown in FIGURE 1.5?

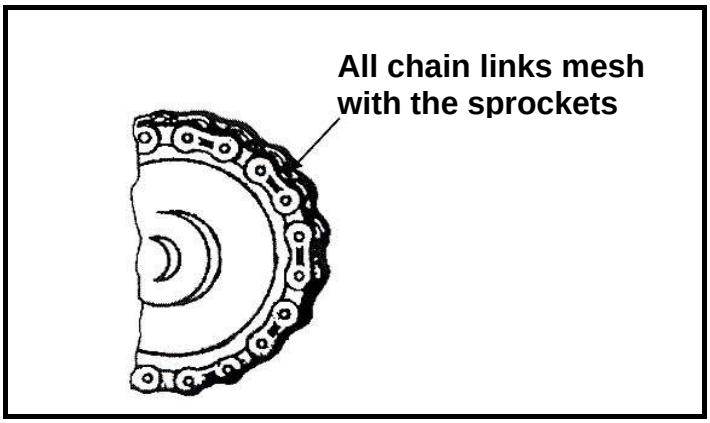

FIGURE 1.5

A Measure the inside diameter of the sprocket wheel.
B Compare the teeth sizes with the selection of chains of different sizes.
C Insert a chain tensioner.
D Avoid grease on the chain. (1)

1.16 What distance (X) will the piston move if the crank moves through a distance of 25 mm, as indicated in FIGURE 1.6, and rotates through 180°?

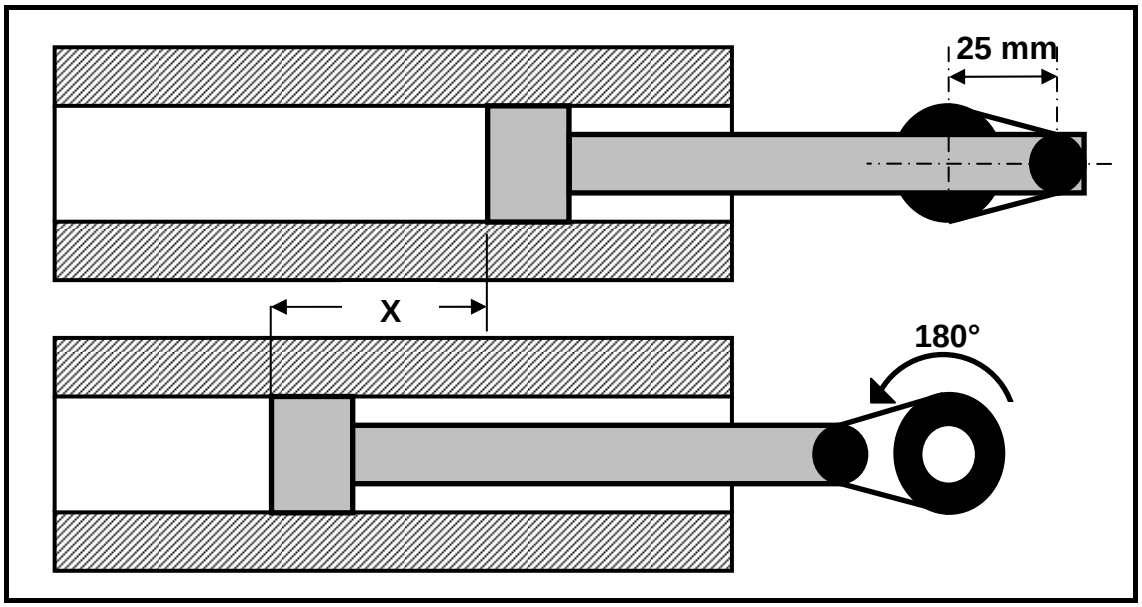

FIGURE 1.6

A 50 mm
B 25 mm
C 12,5 mm
D 100 mm (1)

1.17 Identify the type of thread shown in FIGURE 1.7.

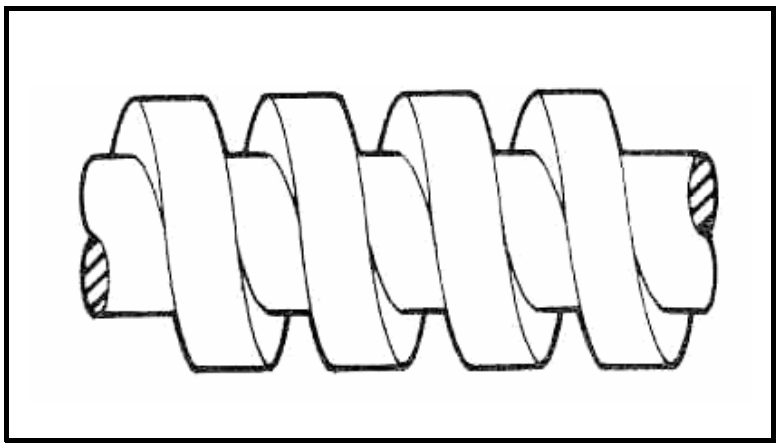

FIGURE 1.7

A V-screw thread
B Square screw thread
C Acme screw thread
D Trapezium screw thread (1)

1.18 Define a *cam follower* as shown in FIGURE 1.8.

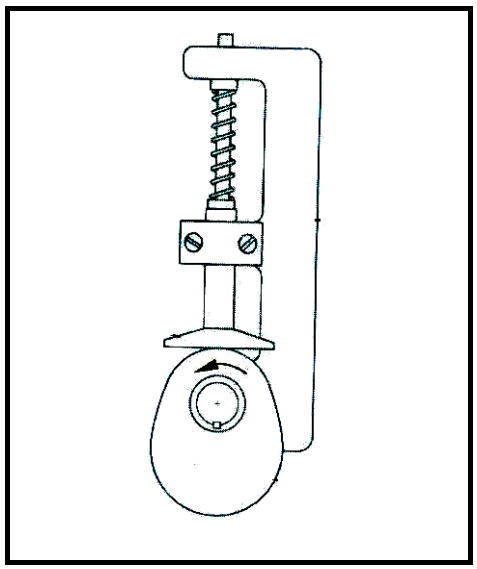

FIGURE 1.8

A A metal part fixed to an axle
B A device that rotates on a shaft
C A device that firmly holds the guide against the cam profile
D A device designed to move up and down, following the cam (1)

1.19 What is the purpose of the primary function of a turbocharger in an internal combustion engine?

A To increase the fuel consumption in relation to engine output
B To increase the volumetric efficiency of the engine
C To decrease the compression pressure of the engine
D To decrease the atmospheric pressure of the engine (1)

1.20 What will the volumetric efficiency be if a 100 mm^3 blower displaces 83 mm^3 per revolution?

A 83%
B 17%
C 103%
D 100% (1)

[20]

QUESTION 2: TOOLS AND EQUIPMENT

2.1 Mr Zama conducted a dry compression test. The test indicated that cylinder number three had a very low reading. After conducting a wet compression test, the reading was the same.

2.1.1 Name the next test you will conduct to find the cause for the loss of compression in cylinder number three. (1)

2.1.2 Describe, in point form, the test you will conduct in QUESTION 2.1.1. (11)

2.2 When assembling the cylinder head, the valve spring must be tested before installation. Give TWO reasons why the valve spring needs to be tested. (2)

2.3 What does the abbreviation CNC stand for in terms of lathes and milling machines? (1)

2.4 Most welding companies make extensive use of MAGS/MIGS welding equipment for their welding.

2.4.1 Name THREE advantages of MAGS/MIGS welding. (3)

2.4.2 Name TWO gases used in MAGS/MIGS welding. (2)
[20]

QUESTION 3: MATERIALS

3.1 Give TWO reasons for using carbon fibre in the manufacture of bicycle frames. (2)

3.2 Which of the materials, A or B, shown in FIGURE 3.1 below would be the stiffer of the two if they were subjected to the same force? Give a reason for your answer.

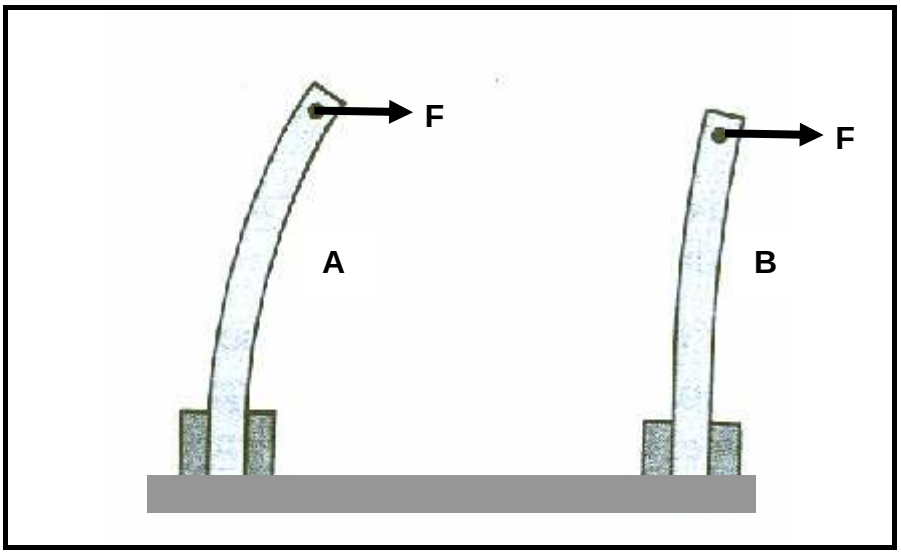

FIGURE 3.1 (3)

3.3 The materials traditionally used in the manufacturing industry are being replaced at an alarming rate by a new generation of materials like non-ferrous alloys.

3.3.1 What do you understand by a *non-ferrous alloy*? (2)

3.3.2 Name THREE examples of non-ferrous alloys. (3)

3.4 FIGURE 3.2 shows a cross-sectional view of a bush and a part of an aluminium shaft of a model car which is subjected to a low speed. A bush that will ensure low friction and low maintenance needs to be manufactured. No lubrication is allowed.

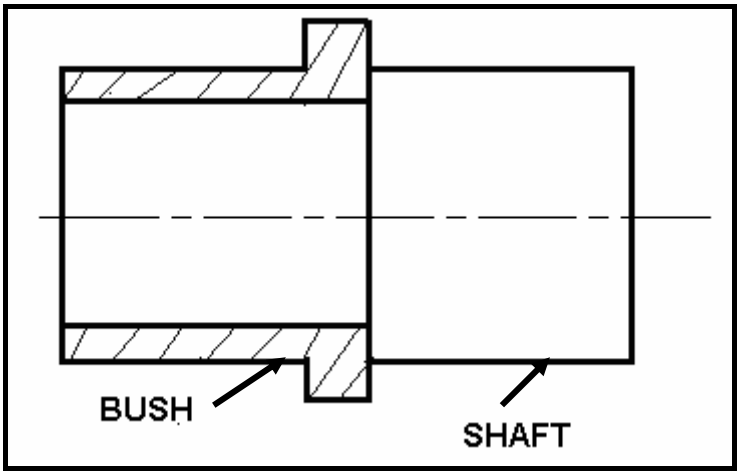

FIGURE 3.2

3.4.1 Name TWO possible thermosetting plastics that would be suitable for the bush. (2)

3.4.2 Name FOUR properties applicable to both materials named in QUESTION 3.4.1 to support your choice. (4)

3.5 Name TWO elements used to manufacture soft solder. (2)

3.6 Name TWO properties of silver solder. (2)
[20]

QUESTION 4: SAFETY, TERMINOLOGY AND JOINING METHODS

4.1 John is using a hydraulic press to fit bearings onto a shaft. State FOUR safety rules for the safe usage of a hydraulic press. (4)

4.2 Andy must see to the safe handling and storage of gas cylinders. Which FOUR safety rules must he take into consideration for the safe handling and storage of the gas cylinders? (4)

4.3 Calculate the feed in millimetres per minute of a 120 mm diameter cutter with 40 teeth, operating at a cutting speed of 100 metres per minute and a feed of 0,1 mm per tooth. (6)

4.4 A spur gear with 67 teeth must be machined onto a work piece. (Hint: Use N = 70 divisions or A = 70 divisions for the calculations.) The dividing-head ratio is 40 : 1.

4.4.1 Calculate the indexing needed for the operation. (5)

4.4.2 Calculate the change gears that must be installed onto the dividing head. (5)

4.4.3 Name the direction of rotation of the index plate in relation to the index crank. (1)

4.5 A gear train with four gears, gears A, B, C and D, which mesh with each other, are shown in FIGURE 4.1 below. The system is used as a reduction gearbox for an industrial washing machine. Use the information in FIGURE 4.1 to answer the following questions.

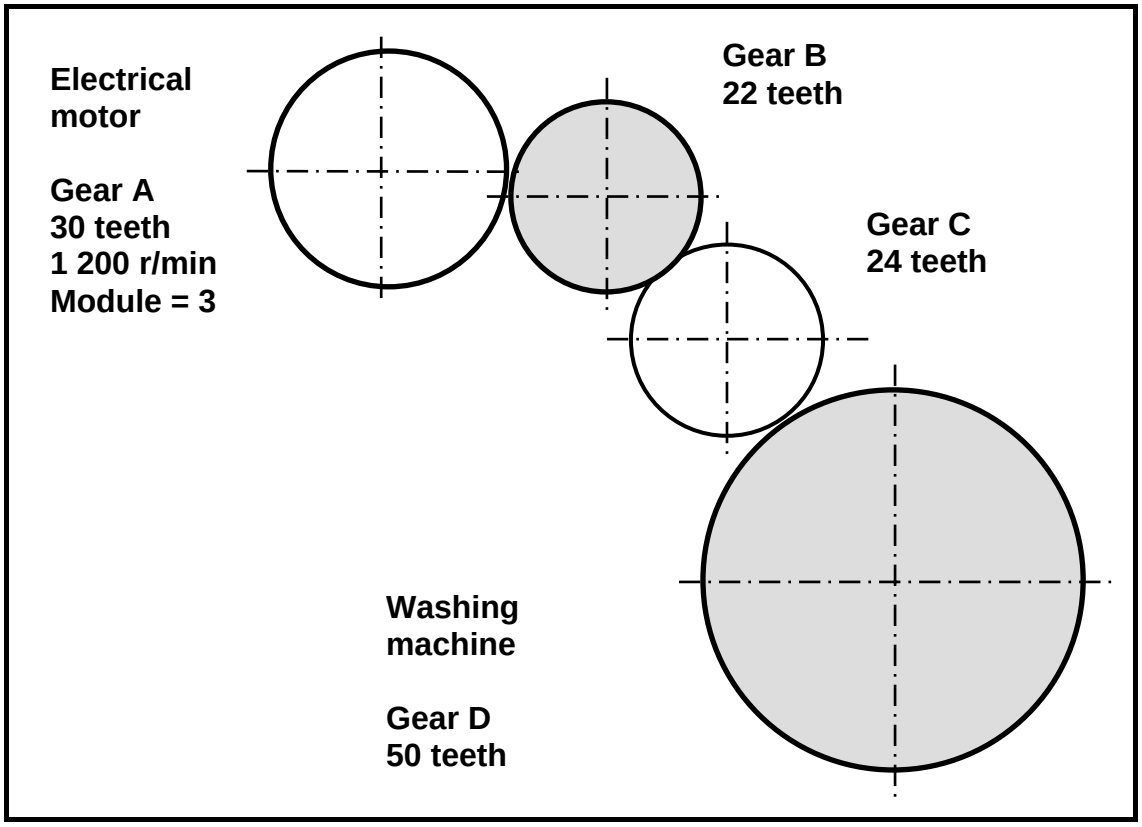

FIGURE 4.1

4.5.1 What is gear A known as? (1)

4.5.2 What will the direction of rotation of gear C be, if the electrical motor rotates in a clockwise direction? (1)

4.5.3 What is gear D known as? (1)

4.5.4 Calculate the rotational frequency (N) of gear B. (3)

4.5.5 Calculate the pitch-circle diameter (PCD) of gear A. (2)

4.5.6 Calculate the outside diameter of gear A. (2)

4.5.7 Calculate the dedendum of gear C. (2)

4.6 Ben is working for Weldco in the test laboratory. His work is to do weld quality tests on all mild steel products. Help Ben by answering the following questions:

4.6.1 Name TWO causes of porosity in a welded joint. (2)

4.6.2 Name ONE step that needs to be followed to prevent porosity in a welded joint. (1)

4.6.3 Name TWO causes of poor fusion of a welded joint. (2)

4.6.4 Name ONE step that needs to be followed to prevent poor fusion of a welded joint. (1)

4.6.5 Explain how a liquid dye penetration test is done on a welded joint. (7)
[50]

QUESTION 5: MAINTENANCE AND TURBINES

5.1 Lubrication is one of the most important aspects in prolonging the life of mechanical parts.

5.1.1 State FIVE properties of good lubricating oil. (5)

5.1.2 Define the term *viscosity* of oil. (2)

5.1.3 Where will you use EP (extreme pressure) oils? (2)

5.1.4 What does the abbreviation SAE stand for regarding engine oil? (1)

5.1.5 Give FOUR reasons for using cutting fluid. (4)

5.1.6 Choose an item from COLUMN B that matches a term in COLUMN A. Write only the letter (A–D) next to the question number (a–d) in the ANSWER BOOK.

COLUMN A		COLUMN B	
(a)	Engine	A	hydraulic oil
(b)	Gearbox	B	SAE 20W50
(c)	Differential	C	soluble oil
(d)	Power steering	D	extreme pressure oil (EP 90)

(4 x 1) (4)

5.1.7 Name TWO functions of automatic transmission fluid. (2)

5.2 A vehicle's performance output can be increased by using a blower. FIGURE 5.1 shows a type of blower which can be used.

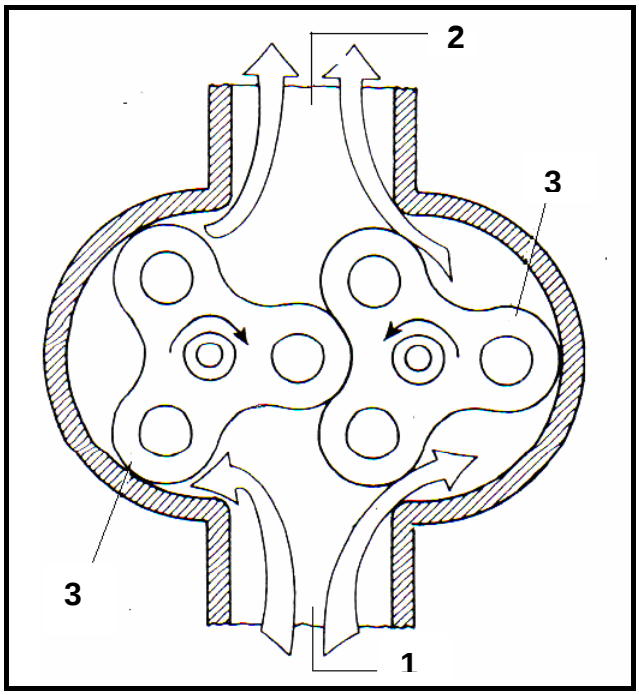

FIGURE 5.1

5.2.1 Identify the type of blower shown in FIGURE 5.1. (1)

5.2.2 Label the parts numbered 1 to 3. (3)

5.2.3 Explain the operation of the blower in FIGURE 5.1. (5)

5.3 Give THREE reasons for fitting a supercharger to an engine. (3)

5.4 Which methods are used to drive a supercharger and turbocharger? (2)

5.5 State TWO uses of steam turbines. (2)

5.6 State FOUR advantages of steam turbines. (4)
[40]

QUESTION 6: FORCES AND SYSTEMS AND CONTROL

6.1 A hydraulic system is being used to put machine parts into position during the assembling process of a machine. The specifications of the system are represented diagrammatically in FIGURE 6.1. Show ALL units.

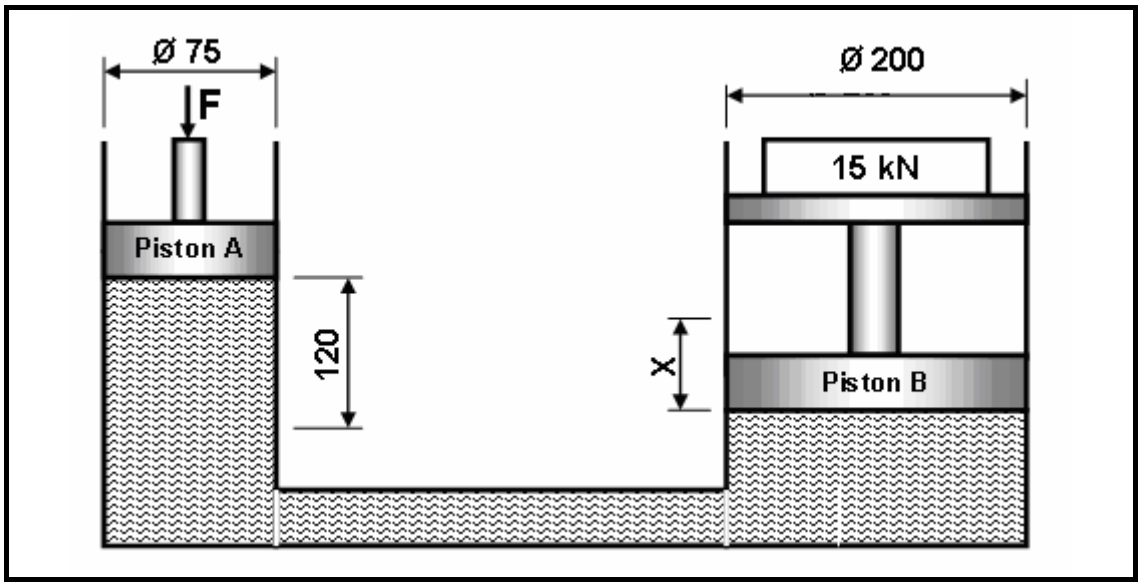

FIGURE 6.1

Determine, by means of calculations, the following:

6.1.1 The fluid pressure in the hydraulic system when in equilibrium (6)

6.1.2 The force (F) that must be exerted onto piston A to lift the load of 15 kN on piston B (6)

6.1.3 The distance X, in millimetres, that piston B will move if piston A completes 16 strokes (6)

6.2 A load of 30 kN causes a compressive stress of 6 MPa in a square brass bar. The original length of the bar is 200 mm and Young's modulus for brass is 90 GPa.

Determine, by means of calculations, the following:

6.2.1 The side length, in millimetres, of the resistance surface of the square brass bar (8)

6.2.2 The strain caused by the load (4)

6.2.3 The change in length, in millimetres, caused by the load (3)

6.3 The V-belt drive system of a compressor is shown in FIGURE 6.2. The driver pulley of the belt drive system rotates at 1 440 r/min. The driver pulley has a diameter of 475 mm and the driven pulley has a diameter of 180 mm. The thickness of the belt used in this system is 12 mm.

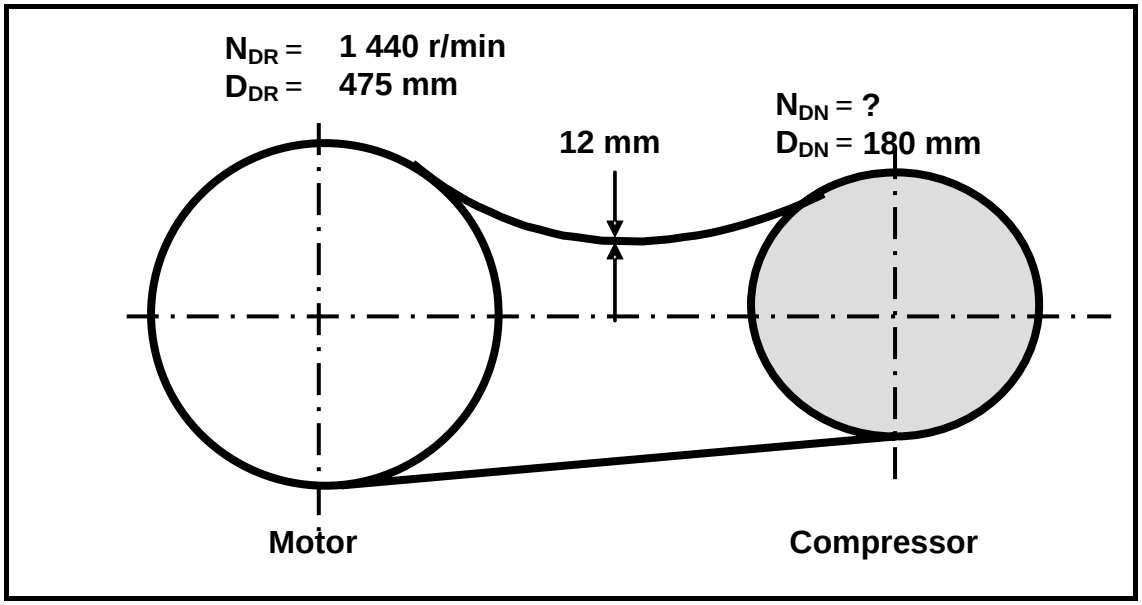

FIGURE 6.2

Determine, by means of calculations, the following:

6.3.1 The rotation frequency of the driven pulley in r/min (5)

6.3.2 The belt speed of the system in metres per second (3)

6.4 A single-plate friction clutch has an effective diameter of 0,28 m. The clutch plate has friction material on both sides. The material has a friction co-efficient of 0,3. The total applied force on the pressure plate is 4 kN.

Calculate and state the correct units for the following:

6.4.1 The maximum torque that can be transmitted (5)

6.4.2 The power transmitted at 3 500 r/min (4)
[50]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 12

1. BELT DRIVES

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

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

1.3 $Belt\ mass = Area \times length \times density$ $(A = thickness \times width)$

1.4 $Speed\ ratio = \frac{Diameter\ of\ driven\ pulley}{Diameter\ of\ driver\ pulley}$

1.5 $N_1 D_1 = N_2 D_2$

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

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

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

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

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

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

2. FRICTION CLUTCHES

2.1 $Torque\ (T) = \mu WnR$

$\mu = coefficient\ of\ friction$

$W = total\ force$

$n = number\ of\ friction\ surfaces$

$R = effective\ radius$

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

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

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 $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

4.3 $Work\ done = force \times distance$

4.4 $Volume = Cross\text{-}sectional\ area \times stroke\ length\ (l\ or\ s)$

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

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

7. SCREW THREADS

7.1 $$Pitch\ diameter = Outside\ diameter - ½\ pitch$$

7.2 $$Pitch\ circumference = \pi \times pitch\ diameter$$

7.3 $$Lead = pitch \times number\ of\ starts$$

7.4 $$Helix\ angle:\ \tan Ø = \frac{Lead}{Pitch\ circumference}$$

7.5 $$Leading\ tool\ angle = 90° - (helix\ angle + clearance\ angle)$$

7.6 $$Following/Trailing\ angle = 90° + (helix\ angle - clearance\ angle)$$

7.7 $$Number\ of\ turns = \frac{height}{lead}$$

8. GEAR DRIVES

8.1 $$Power\ (P) = \frac{2\pi NT}{60}$$

8.2 $$Gear\ ratio = \frac{Product\ of\ the\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ the\ number\ of\ teeth\ on\ driving\ gears}$$

8.3 $$\frac{N_{input}}{N_{output}} = \frac{Product\ of\ the\ number\ of\ teeth\ on\ driven\ gears}{Product\ of\ the\ number\ of\ teeth\ on\ driving\ gears}$$

8.4 $$Torque = force \times radius$$

8.5 $$Torque\ transmitted = gear\ ratio \times input\ torque$$

8.6 $$Module\ (m) = \frac{Pitch\text{-}circle\ diameter\ (PCD)}{Number\ of\ teeth\ (T)}$$

8.7 $$N_1T_1 = N_2T_2$$

8.8 $$Pitch\text{-}circle\ diameter\ (PCD) = \frac{circular\ pitch\ (CP) \times number\ of\ teeth\ (T)}{\pi}$$

8.9 $$Outside\ diameter\ (OD) = PCD + 2\ module$$

8.10 $$Addendum\ (a) = module\ (m)$$

8.11 $$Dedendum\ (b) = 1{,}157\ m \quad or \quad Dedendum\ (b) = 1{,}25\ m$$

8.12 $$Cutting\ depth\ (h) = 2{,}157\ m \quad or \quad Cutting\ depth\ (h) = 2{,}25\ m$$

8.13 $$Clearance\ (c) = 0{,}157\ m \quad or \quad Clearance\ (c) = 0{,}25\ m$$

8.14 $$Circular\ pitch\ (CP) = m \times \pi$$

9. CINCINNATI 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*

9.1 $Simple\ indexing = \frac{40}{n}$ *(where n = number of divisions)*

9.2 *Change gears:*

$$\frac{Dr}{Dv} = (A - n) \times \frac{40}{A} \quad or \quad \frac{Dr}{Dv} = \frac{(A-n)}{A} \times \frac{40}{1} \quad or \quad \frac{Dr}{Dv} = (N-n) \times \frac{40}{N}$$

10. CALCULATIONS OF FEED

10.1 $Feed\ (f) = f_1 \times T \times N$

Where: f *= feed in millimetres per minute*

f_1 *= feed per tooth in millimetres*

T *= number of teeth on cutter*

N *= number of revolutions of cutter per minute*

10.2 $Cutting\ speed\ (V) = \pi \times D \times N$

Where: D *= diameter of the cutter in metres*

ANSWER SHEET

CENTRE NUMBER:													
EXAMINATION NUMBER:													

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

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basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

NOVEMBER 2011

MEMORANDUM

MARKS: 200

This memorandum consists of 14 pages.

ANSWER SHEET

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

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QUESTION 2: TOOLS AND EQUIPMENT

2.1 **Cylinder leakage test:**

2.1.1 Cylinder Leakage Test ✓ (1)

2.1.2 **Procedure for cylinder leakage test:**

- Run the engine until normal operating temperature. ✓
- Remove the spark plug from cylinder number three. ✓
- Install cylinder leakage tester to the spark plug hole of cylinder number three. ✓
- Remove the oil filler cap, radiator filler cap as well as the air filter. ✓
- Turn the crankshaft pulley until piston number three is at TDC (Power stroke) ✓
- Apply air pressure to cylinder. ✓
- Listen at the carburettor for a hissing noise. (Inlet valve is leaking) ✓
- Listen at the exhaust pipe for a hissing noise. (exhaust valve is leaking) ✓
- Listen at the dipstick for a hissing noise. (Piston rings are worn) ✓
- Listen at the oil filler hole for a hissing noise. (Piston rings are worn) ✓
- Look for bubbles in the radiator water, if so the cylinder head gasket is blown or the cylinder block is cracked. ✓ (11)

[50% (6 marks) will be credited for the steps related to any type of test other than that mentioned in 2.1.1]

2.2 **Spring tester:**

- Squareness/Roundness ✓ or (specifications of length and pressure) (2)
- Correct tension✓

2.3 Computer Numerical Control✓ (1)

2.4 **Metal arc gas shielded:**

2.4.1 **Advantages**

- Can weld in any position. ✓
- Higher disposition rate. ✓
- Less operator skill required. ✓
- Long welds can be made without stops and starts. ✓
- Minimal post-weld cleaning / no slag removal is required. ✓
- Causes less deformation ✓
- Gives better finish ✓
- Faster than arc welding ✓

Easy operation ✓ **Any 3 X 1** (3)

2.4.2 **Gasses**
- Argon ✓ and CO_2 ✓ (2)

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QUESTION 3: MATERIALS

3.1 **Carbon fibre:**
- It gives a smooth finish✓
- Light in weight✓
- Resistant to corrosion✓
- Easy to mould✓
- Its tough✓
- It's strong ✓ **Any 2 X 1** (2)

3.2 **Stiffness of materials:**
Material B is the stiffer✓
Reason: Material B is more resistant to a bending deformation✓✓ (3)

3.3 **Non-ferrous alloys:**

3.3.1 A non-ferrous alloy is a metal that has a combination of two or more non-ferrous metals. ✓✓ (2)

3.3.2 **Examples:**
- Brass✓
- Bronze✓
- White metal✓
- Duralumin✓
- Solder✓
- Silver solder✓ **Any 3 X 1** (3)

3.4 **Composite:**

3.4.1 **Thermosetting plastics**
- Teflon✓
- Nylon✓ (2)

3.4.2 **Properties of Teflon and nylon to support choice:**
- High friction resistance✓
- Light in weight✓
- Easy to work with✓
- Provides a smooth finish✓
- Needs no lubrication ✓
- No/low maintenance ✓
- Corrosion free ✓
- Poor conductor of electricity ✓ **Any 4 X 1** (4)

3.5 **Soft solder**
Lead ✓ and tin ✓or Antimony (2)

3.6 **Silver solder**
High melting point ✓
Resistant to corrosion✓ (2)

good conductor
give a strong bead
used to join a variety of materials

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QUESTION 4: SAFETY, TERMINOLOGY AND JOINING METHODS

4.1 **Hydraulic press:**

- Make sure the object is firmly secured. ✓
- Make sure pins holding the beam is fitted properly. ✓
- Check pins for wear. ✓
- Check for oil leaks. ✓
- Make sure the area around the press is clean and free from oil. ✓
- Release pressure after operation ✓
- Personal safety ✓
- Safety guards ✓ (4)

Any 4 X 1

4.2 **Gas cylinders:**

- Store oxygen and acetylene separately.✓
- Store full and empty cylinders apart. ✓
- Keep cylinders in a cool place away from heat. ✓
- Place cylinders in an upright position. ✓
- Don't drop cylinders. ✓
- Cylinder heads must be on. ✓
- Keep cylinders away from oil or grease. ✓
- Don't hammer on cylinders. ✓
- Secure cylinders properly. ✓
- Do not transport in horizontal position ✓ **Any 4 X 1** (4)

4.3 **Cutting feed:**

$$V = \pi DN$$

$$N = \frac{V}{\pi D} \quad ✓$$

$$N = \frac{100}{\pi \times 0{,}12} \quad ✓$$

$$N = 265{,}258\,2385\ rpm \quad ✓$$

$$f = f_1 \times T \times N \quad ✓$$

$$f = 0{,}1 \times 40 \times 265{,}258 \quad ✓$$

$$f = 1061{,}03\ mm/\min \quad ✓$$

(6)

4.4 **Indexing:**

4.4.1

$$\textbf{Indexing} = \frac{\textbf{40}}{\textbf{A}} \quad ✓$$

$$= \frac{\textbf{40}}{\textbf{70}} \quad ✓$$

$$= \frac{\textbf{4}\times\textbf{4}}{\textbf{7}\times\textbf{4}} \text{ or } \frac{4\times6}{7\times6} \text{ or } \frac{4}{7} \quad ✓$$

$$= \frac{\textbf{16}}{\textbf{28}} \textbf{ or } \frac{\textbf{24}}{\textbf{42}} \textbf{ or } \frac{\textbf{28}}{\textbf{49}} \quad ✓$$

16 holes on the 28 – hole cir ✓

24 holes on the 42 - hole circ

28 holes on the 49 - hole circ..

(5)

4.4.2

$$\frac{D_r}{D_v} = (A-n)\times\frac{40}{A} \quad ✓$$

$$\frac{D_r}{D_v} = (70-67)\times\frac{40}{70} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{120}{70} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{12\times4}{7\times4} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{48}{28}$$

No full turn, 16 holes on the 28-hole circle with change gears $\frac{48}{28}$ *or* ✓

No full turn, 24 holes on the 42-hole circle with change gears $\frac{48}{28}$ *or*

No full turn, 28 holes on the 49-hole circle with change gears $\frac{48}{28}$

(5)

4.4.3 Same direction/clockwise/positive ✓ (1)

4.5 **Gear drives:**

4.5.1 Driving gear /electrical motor gear✓ (1)

4.5.2 Clockwise direction✓ (1)

4.5.3 Output/final/driven gear/ washing machine gear✓ (1)

4.5.4 **Gear B**

$N_A \times T_A = N_B \times T_B$ ✓
$1200 \times 30 = N_D \times 22$ ✓
$N_B = 1636\ rpm$ ✓ (3)

4.5.5 **Gear A**

$PCD = m \times T$
$= 3 \times 30$ ✓
$= 90\ mm$ ✓ (2)

4.5.6 **Outside diameter**

$Outside\ diameter\ (OD) = PCD + 2 \times Module$
$= 90 + (2 \times 3)$ ✓
$= 96\ mm$ ✓ (2)

4.5.7 **Dedendum**

$Dedendum = 1{,}157 \times m$ ✓
$= 1{,}157 \times 3$
$= 3{,}471\ mm$ ✓

OR

$Dedendum = 1{,}25 \times m$ ✓
$= 1{,}25 \times 3$
$= 3{,}75\ mm$ ✓ (2)

4.6 **Weld defects and testing:**

4.6.1 **Causes porous weld:**

- Atmospheric contamination. ✓
- Surface contamination. ✓
- Dirty or wet electrodes. ✓
- Rusted MIG wire. ✓
- Type of welder ✓
- Current too high ✓
- Poor quality material ✓
- Incorrect method ✓
- Dirty welding rods ✓

Any 2 X 1 (2)

4.6.2 **Prevention:**

- Clean the workpiece. ✓
- Use clean, dry electrodes. ✓
- Use correct electrodes including low hydrogen electrodes ✓ **Any 1 X 1** (1)

4.6.3 **Causes of poor fusion:**

- Welding current to low or too fast. ✓
- Welding pool too wide or too large✓
- Wrong joint preparation root gap & chamfering). ✓
- Welding electrode to thick. ✓ **Any 2 X 1** (2)

4.6.4 **Prevention:**

- Use correct current. ✓
- Be sure to melt the sides of the groove. ✓
- Groove must be free of other metals. ✓
- Width of the electrode must be small enough to fit in groove. ✓ **Any 1 X 1** (1)

4.6.5 **Liquid dye penetration test:**

- Clean the weld that needs to be tested. ✓
- The dye is sprayed onto the welded surface.✓
- Allowed dye to penetrate all the cracks. ✓
- Excess dye is cleaned away with a cleaning agent. ✓
- Allowed surface to dry. ✓
- Spray a developer onto the surface to bring out the dye trapped in cracks. ✓
- The dye will show all the surface defects ✓ (7)

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QUESTION 5: MAINTENANCE AND TURBINES

5.1 **Lubrication:**

5.1.1 **Properties**

- Viscosity must be correct. ✓
- It must resist oxidation. ✓
- It must avoid foaming. ✓
- Resist carbon forming. ✓
- It must prevent corrosion **or** rust✓.
- It must resist extreme pressures. ✓
- Pour point ✓
- Resistance to temperature change ✓ **Any 5 X 1** (5)

5.1.2 Viscosity of oil refers to the resistance of oil to flow./ thickness of oil ✓✓ (2)

5.1.3 **EP Oils**

- Manual gearbox✓
- Final drive or differential✓
- Heavy duty machinery **Any 2 X 1** (2)

5.1.4 Society of Automotive Engineers ✓ (1)

5.1.5 **Cutting Fluid**

- Acts as lubricant ✓
- Prevents chips from sticking ✓
- Improves quality of finish ✓
- Keeps the work piece cool ✓
- Keeps the cutting tool cool ✓
- Gives the cutting tool a longer life span ✓
- Wash away/remove chips/swarfs **Any 4 x 1** (4)

5.1.6 **Gear Lubrication**

COLUMN A	COLUMN B	
Engine	SAE 20W50	B✓
Gearbox	Extreme pressure oil (EP 90)	D✓
Differential	Extreme pressure oil (EP 90)	D✓
Power steering	Hydraulic oil	A✓ (4)

5.1.7 **Automatic transmission Fluid**

- Transmitting power via torque converter ✓
- Acting as hydraulic fluid via servo cylinder ✓
- Acts as a heat-transfer medium ✓
- Acts as lubricant for gears and bearings ✓ **Any 2 X 1** (2)

5.2 **Blower:**

5.2.1 Roots blower ✓ (1)

5.2.2 1. Inlet ✓
2. Outlet ✓
3. Rotors ✓ (3)

5.2.3 **Operation**

- The engine drives the rotors by means of gears or chain ✓
- Air is trapped between the rotor and aluminium casing. ✓
- This air is carried around the outside of the rotor and is pushed into a decreasing volume. ✓
- This raises the pressure of the air with the rotational speed of the rotors. ✓
- The air is forced into the inlet manifold and then fed into the cylinders. ✓ (5)

5.3 **Superchargers**

- To fill the cylinder with air pressure higher than atmospheric pressure. ✓
- To increase the compression pressure in the cylinder. ✓
- To increase volumetric efficiency of the engine. ✓
- No lag in relation to turbo charger ✓
- Obtain more power ✓ **Any 3 X 1** (3)
-

5.4 **Superchargers and turbochargers**

- Supercharger is mechanically driven by gears or a belt. ✓
- Turbocharger is driven by the exhaust gases. ✓ (2)

5.5 **Steam turbine uses**

- To drive generators to generate electricity. ✓
- To operate ships. ✓
- To operate pumps ✓ **Any 2 X 1** (2)

5.6 **Advantages of steam turbines**

- It is compact. ✓
- No lubrication is required. ✓
- Steam turbine speeds can be more accurately regulated. ✓
- A variety of fuels can be used to obtain steam. ✓
- Steam turbines are more economical. ✓
- Higher speeds can be obtained as compared to internal combustion engines. ✓
- Low maintenance ✓ **Any 4 X 1** (4)

[40]

QUESTION 6: FORCES AND SYSTEMS AND CONTROL

6.1 Hydraulics:

6.1.1 Fluid pressure:

$$A_B = \frac{\pi D^2}{4} \quad \checkmark$$

$$A_B = \frac{\pi(0,2)^2}{4} \quad \checkmark$$

$$A_B = 31,41593\times10^{-3}\,m^2 \quad \checkmark$$

$$P = \frac{F_B}{A_B} \quad \checkmark$$

$$P = \frac{15\times10^3}{31,41593\times10^{-3}} \quad \checkmark$$

$$= 477464,8293\,Pa$$

$$= 0,48\ MPa \quad \checkmark$$

(6)

6.1.2 Force F on piston A:

$$A_A = \frac{\pi D^2}{4} \quad \checkmark$$

$$A_A = \frac{\pi\times(0,075)^2}{4} \quad \checkmark$$

$$A_A = 4,4178\times10^{-3}m^2 \quad \checkmark$$

$$P_A = P_B$$

$$P_A = \frac{F_A}{A_A} \quad \checkmark$$

$$F_A = P_A \times A_A \quad \checkmark$$

$$F_A = \left(0,48\times10^6\right)\left(4,42\times10^{-3}\right)$$

$$F_A = 2,10935\ kN \quad \checkmark$$

$$= 2,11\ kN$$

$$or\ \frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \checkmark\checkmark$$

$$F_1 = \frac{F_2 \times A_1}{A_2} \quad \checkmark$$

$$= \frac{15\times10^3\times4,4178\times10^{-3}}{31,41593\times10^{-3}} \quad \checkmark\checkmark$$

$$= 2,1093\ kN \quad \checkmark$$

$$= 2,11\ kN$$

(6)

6.1.3 **Distance 'X':**

$$V_B = V_A \quad ✓$$

$$A_B \times X = A_A \times L_A \quad ✓$$

$$X = \frac{A_A \times L_A}{A_B} \quad ✓$$

$$X = \frac{(4{,}42\times10^{-3})(0{,}12)}{31{,}41\times10^{-3}} \quad ✓$$

$$X = 16{,}87499773\ mm/stroke \quad ✓$$

$$X = 16{,}87499773\times16$$

$$X = 269{,}99\ mm \quad ✓$$

$$= 270\ mm$$

(6)

6.2 **Stress and strain:**

6.2.1 **Side length:**

$$\sigma = \frac{F}{A} \quad ✓$$

$$A = \frac{F}{\sigma} \quad ✓$$

$$A = \frac{30\times10^{3}}{6\times10^{6}} \quad ✓$$

$$A = 5\times10^{-3}m^2$$

$$A = L^2 \quad ✓$$

$$L = \sqrt{A} \quad ✓ ✓$$

$$L = \sqrt{5\times10^{-3}m^2}$$

$$L = 0{,}0707106\,m$$

$$L = 70{,}71\ mm \quad ✓$$

(8)

6.2.2 **Strain:**

$$E = \frac{\sigma}{\varepsilon} \quad ✓$$

$$\varepsilon = \frac{\sigma}{E} \quad ✓$$

$$\varepsilon = \frac{6\times10^{6}}{90\times10^{9}} \quad ✓$$

$$\varepsilon = 0{,}06667\times10^{-3} \quad ✓$$

$$= 6{,}67\times10^{-5}$$

(4)

6.2.3 **Change in length:**

$$\varepsilon = \frac{\Delta \ell}{o\ell} \quad \checkmark$$
$$\Delta \ell = \varepsilon \times o\ell$$
$$\Delta \ell = 6{,}67 \times 10^{-5} \times 200 \quad \checkmark$$
$$= 0{,}013\,\text{mm} \quad \checkmark \qquad (3)$$

6.3 **Belt drives:**

6.3.1 **Rotational frequency of the driven pulley**

$$(D_{DN} + t) \times N_{DN} = (D_{DR} + t) \times N_{DR} \quad \checkmark$$
$$N_{DN} = \frac{(D_{DR} + t) \times N_{DR}}{(D_{DN} + t)} \quad \checkmark$$
$$= \frac{(475+12) \times 1440}{(180+12)} \quad \checkmark$$
$$= \frac{487 \times 1440}{192} \quad \checkmark$$
$$= 3652{,}5\,rpm \quad \checkmark$$

Or

$$N_1 D_1 = N_2 D_2 \quad \checkmark$$
$$N2 = \frac{N_1 D_1}{D_2} \quad \checkmark$$
$$= \frac{475 \times 1440}{180} \quad \checkmark$$
$$= 3800\,\text{rpm} \quad \checkmark \qquad (5)$$

6.3.2 **Belt speed:**

$$V = \frac{\pi (D+t) \times N}{60} \quad \checkmark$$
$$= \frac{\pi (0.475 + 0{,}012) \times 1440}{60} \quad \checkmark$$
$$= 36{,}72\,m.s^{-1} \quad \checkmark \qquad (3)$$

6.4 **Clutches:**

6.4.1 **The maximum torque transmitted:**

$$T = \mu W n R$$
$$T = 0{,}3 \times 4 \times 10^3 \times 2 \times \frac{0{,}28}{2} \quad \checkmark$$
$$= 0{,}3 \times 4 \times 10^3 \times 2 \times 0{,}14 \quad \checkmark\checkmark$$
$$= 336 Nm \quad \checkmark$$
$$\checkmark \qquad (5)$$

6.4.2 **Power transmitted at 3500 rpm in kW:**

$$P = \frac{2\pi NT}{60} \quad \checkmark$$

$$P = \frac{2\pi \times 3500 \times 336}{60} \quad \checkmark\checkmark$$

$$P = 123{,}15\,kW \quad \checkmark$$

(4)
[50]

TOTAL: 200