



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY**

**NOVEMBER 2010**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 21 pages and a 5-page formula sheet.**

**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. A formula sheet is attached to this paper.
5. Show ALL calculations and units. Round off all final answers to TWO decimal places.
6. Candidates may use non-programmable scientific calculators and drawing instruments.
7. The value of gravitational force should be taken as  $10 \text{ m/s}^2$ .
8. Start EACH question on a NEW page.
9. All dimensions are in millimetres unless stated otherwise in the question.
10. Write neatly and legibly.
11. Use the criteria below to assist you in managing your time.

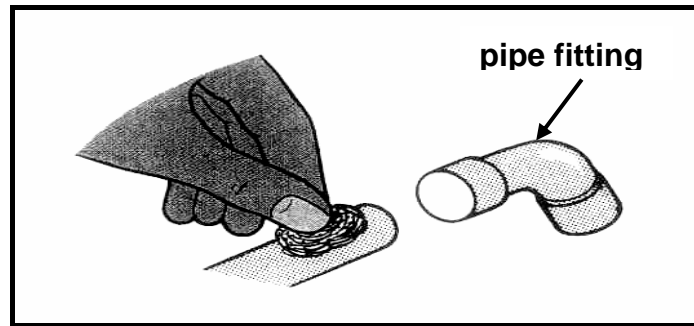
QUESTION	ASSESSMENT STANDARD(S)	CONTENT	MARKS	TIME
1	1 – 9	Multiple-choice questions	20	18 minutes
2	6 and 8	Forces, Systems and Control	50	45 minutes
3	2	Tools and Equipment	20	18 minutes
4	3	Materials	20	18 minutes
5	1, 4 and 5	Safety, Terminology and Joining Methods	50	45 minutes
6	7 and 9	Maintenance and Turbines	40	36 minutes
<b>TOTAL</b>			<b>200</b>	<b>180 minutes</b>

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS**

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.20) in the ANSWER BOOK.

- 1.1 Which of the following safety measures apply to a torsion tester?
- A Make sure the work piece is properly tightened.
  - B Be careful of metal particles coming off after the metal fractures.
  - C Do not hold the test piece with your hands as it may be hot.
  - D All the above-mentioned
- (1)
- 1.2 Which ONE of the following safety procedures does NOT relate to the coil-spring compressor?
- A Make sure that the spring clamp does not slip.
  - B Compress the spring to remove the shock absorber from the suspension.
  - C Use wire or rope to compress the coil spring.
  - D Make sure that the coil spring compressor is in a good working condition.
- (1)
- 1.3 What is determined by a cylinder leakage test?
- A Leaking carburettor
  - B Leaking cylinder sleeve or engine block
  - C Leaking fuel pump
  - D Leaking water pump
- (1)
- 1.4 The main reason for a high carbon monoxide reading when using a gas analyser is ...
- A low compression.
  - B worn valves.
  - C worn piston rings.
  - D a clogged air filter.
- (1)

1.5 Anele has to solder a bronze pipe fitting. What step of the soldering process does FIGURE 1.1 below show?



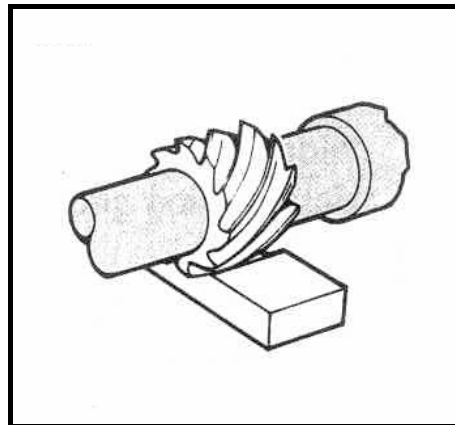
**FIGURE 1.1**

- A Apply flux to the cleaned surface.
- B Allow the joint to cool.
- C Heat the joint and apply solder to the joint.
- D Clean the surface to be joined with steel wool or emery cloth. (1)

1.6 Thermoplastics are materials that ...

- A can be stretched but rapidly return to their original shape.
- B soften under heat and become hard when cooled.
- C form a rigid shape under pressure or heat.
- D is used to manufacture bicycle frames. (1)

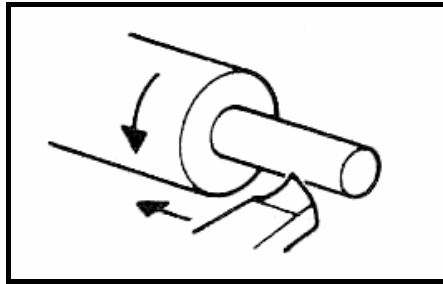
1.7 Identify the type of milling cutter shown in FIGURE 1.2 below.



**FIGURE 1.2**

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

1.8 Which lathe operation is shown in FIGURE 1.3 below?



**FIGURE 1.3**

- A Diameter turning
  - B Facing off
  - C Thread cutting
  - D Boring
- (1)

1.9 What are the disadvantages of downcut milling?

- A A slow cutting feed must be used.
  - B Vibration in the arbor is unavoidable.
  - C Materials with hard scale damage the cutter teeth.
  - D All the above-mentioned
- (1)

1.10 What is the reason for using the nick-break test?

- A To test the skill of the welder
  - B To check for internal defects
  - C To train welders
  - D To approve welds to certain standards
- (1)

1.11 What are the advantages of gang milling?

- A Less friction of teeth in contact
  - B Less grinding is needed to sharpen teeth
  - C Less chattering than when using fine tooth cutters
  - D All the above-mentioned
- (1)

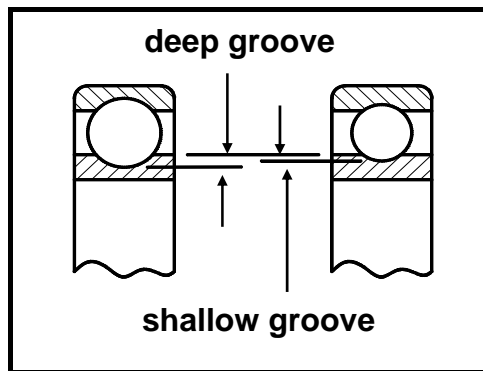
1.12 Stress can be defined or described as an internal force in a material resisting ...

- A a shearing load.
  - B a pulling/tensile load.
  - C a pushing/compressive load.
  - D any load.
- (1)

1.13 What is understood by the term *strain*?

- A Force value required to produce unit area in a tensile specimen
- B A measurement for the extension or contraction of material due to the load
- C Stress value required to produce unit strain in a tensile specimen
- D A ratio of the deformation by application of an external force (1)

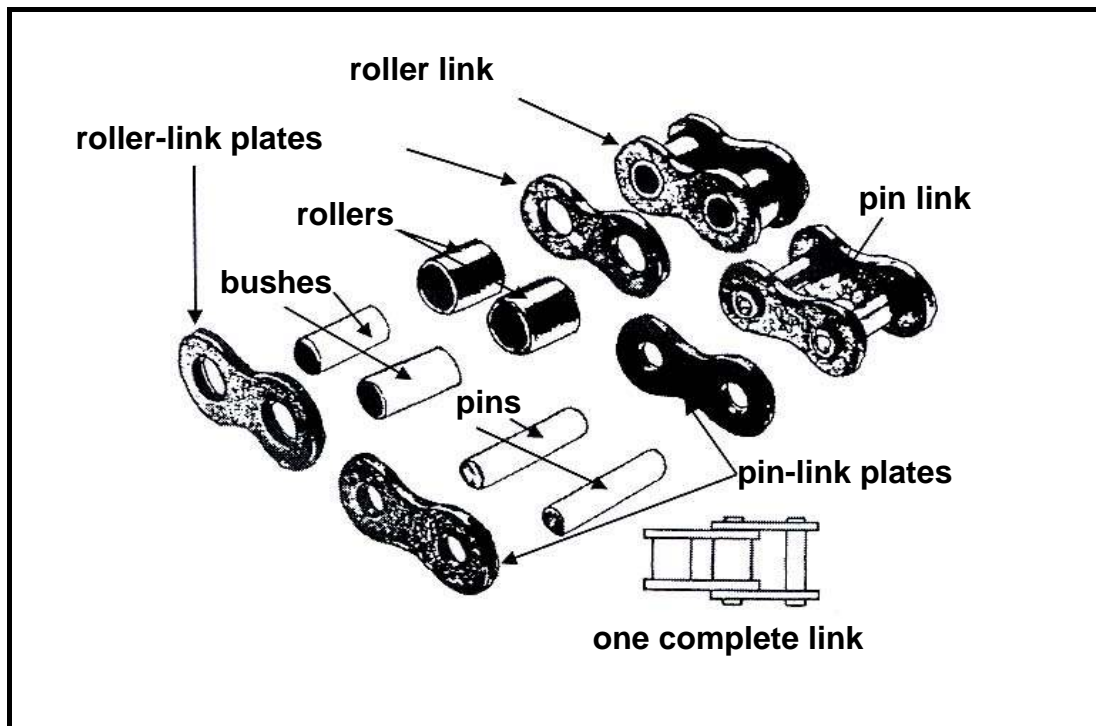
1.14 What is the function of the deep groove ball bearing shown in FIGURE 1.4?



**FIGURE 1.4**

- A For supporting light radial and small axial loads
- B For allowing misalignments between inner and outer rings
- C For supporting high thrust loads
- D For carrying radial and axial thrust loads (1)

- 1.15 Which steps are the most suitable when replacing a roller chain on a chain drive system as shown in FIGURE 1.5 below?



**FIGURE 1.5**

- A Measure the chain length
- B Dismantle the chain
- C Install and join the new chain
- D All the above-mentioned

(1)

1.16 The pulley system shown in FIGURE 1.6 below is ...

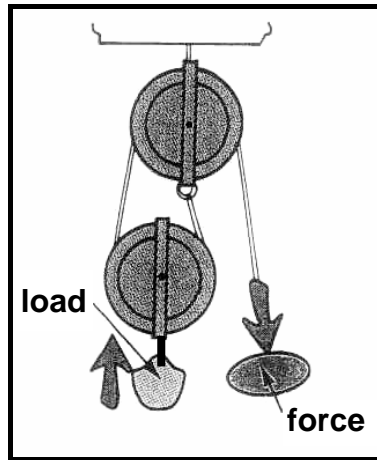


FIGURE 1.6

- A changing direction.
- B multiplying force.
- C multiplying distance.
- D All the above-mentioned

(1)

1.17 FIGURE 1.7 shows a single-start nut and bolt. For each complete rotation of the thread, the nut would move a distance of ...

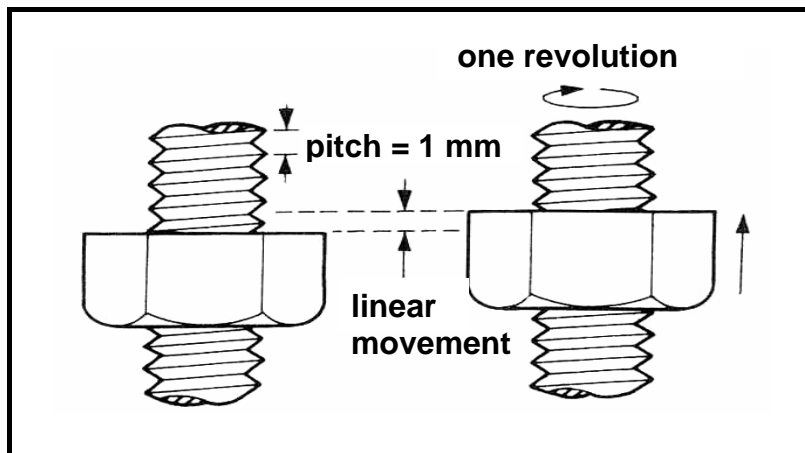


FIGURE 1.7

- A 2 mm.
- B 1 mm.
- C 3 mm.
- D 4 mm.

(1)



1.18 What is the distance **D** moved by the follower for the pear-shaped cam shown in FIGURE 1.8 below, given that  $d_1 = 4 \text{ mm}$  and  $d_2 = 10 \text{ mm}$ ?

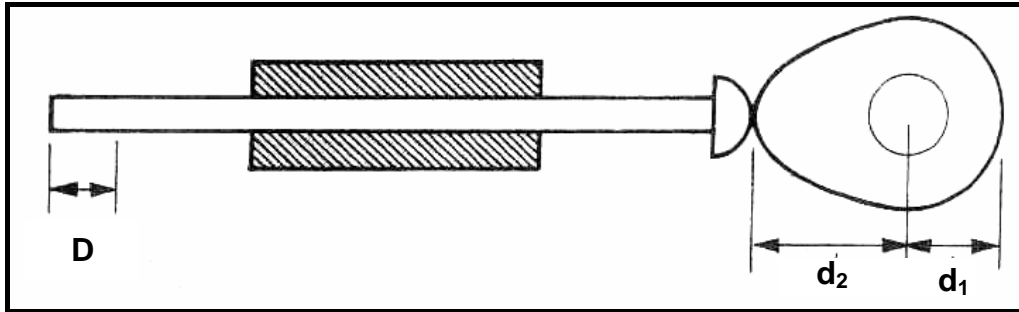


FIGURE 1.8

- A 10 mm
  - B 4 mm
  - C 6 mm
  - D 2,5 mm
- (1)

1.19 What is understood by the term *boost* as related to superchargers?

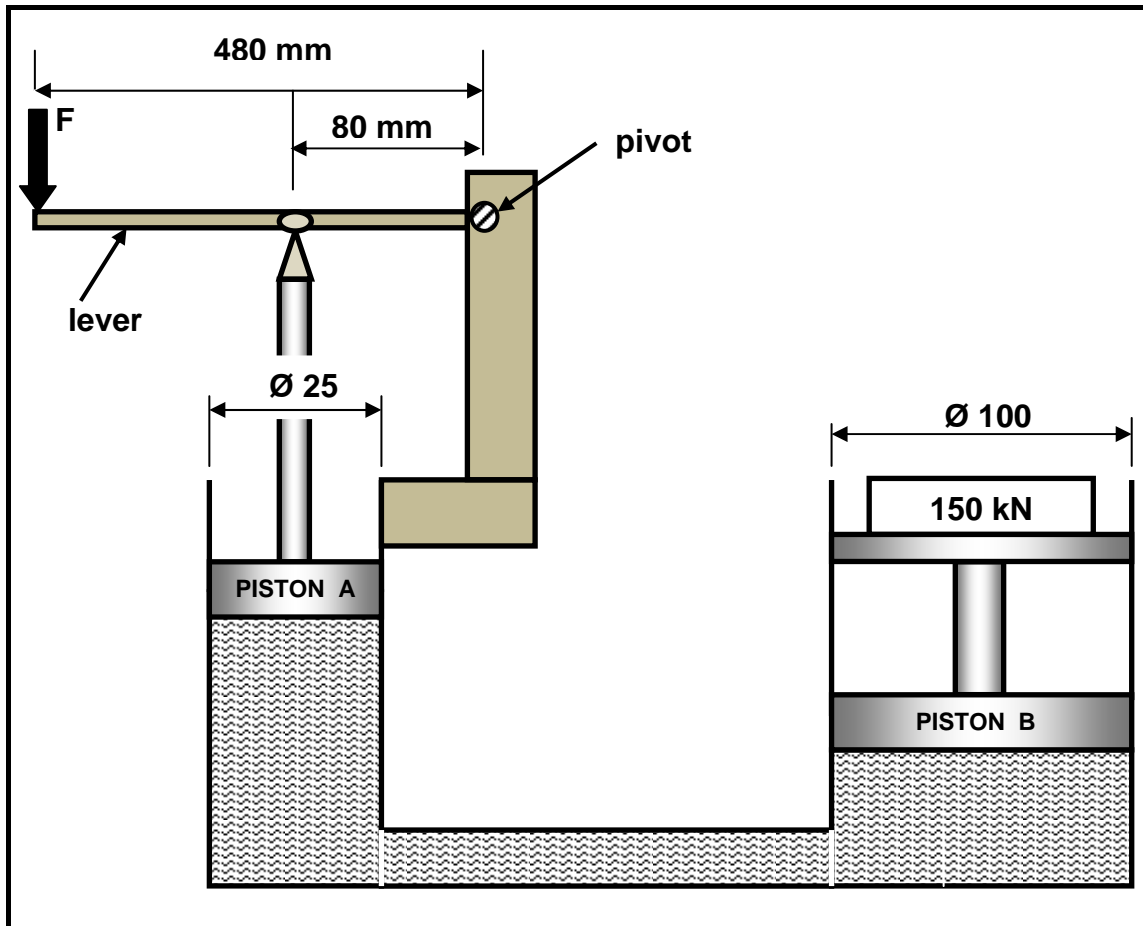
- A The pressure that the supercharger generates in the intake manifold
  - B The pressure that the supercharger generates in the exhaust manifold
  - C Decreased compressive pressure in the cylinder
  - D Decreased exhaust manifold pressure
- (1)

1.20 Which ONE of the following is NOT a blower?

- A Centrifugal blower
  - B Jet blower
  - C Vane blower
  - D Roots blower
- (1)  
**[20]**

**QUESTION 2: FORCES, SYSTEMS AND CONTROL**

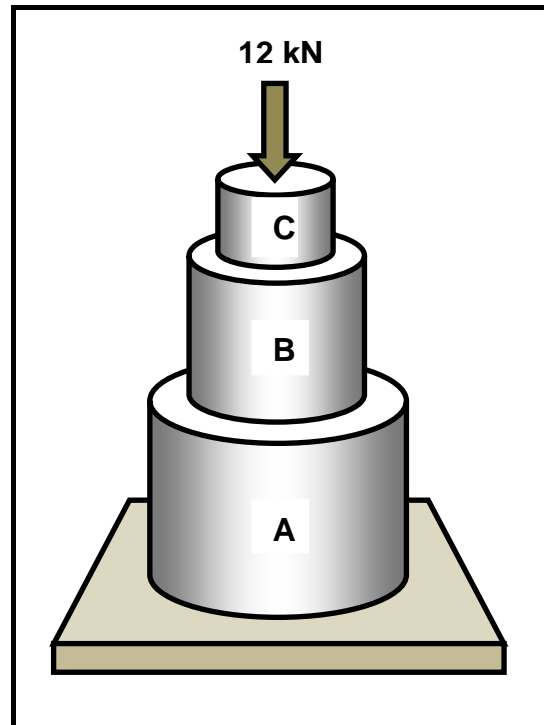
2.1 A lever-controlled hydraulic system, with specifications, is shown diagrammatically in FIGURE 2.1 below.

**FIGURE 2.1**

Determine, by means of calculations, the following:

- 2.1.1 The fluid pressure in the hydraulic system in MPa (4)
- 2.1.2 The force that must be exerted onto PISTON A to lift the load (150 kN) on PISTON B. (Hint: Use the answer to QUESTION 2.1.1.) Give the answer in kN. (4)
- 2.1.3 The force  $F$  that must be exerted onto the lever to lift the load of 150 kN on PISTON B. (Give the answers in N.) (4)

- 2.2 A compressive test needs to be done on a round stepped shaft, shown in FIGURE 2.2 below. The diameter of part A is 100 mm, part B is 70 mm and part C is 50 mm. A compressive load of 12 kN is exerted onto the shaft. The modulus of elasticity for the material is 108 GPa.



**FIGURE 2.2**

- 2.2.1 Identify the part in which the maximum stress will occur and calculate the stress in MPa. (5)
- 2.2.2 Calculate the strain in part A of the stepped shaft. (7)

- 2.3 A compressor, fitted with a pulley, diameter 432 mm, is driven at a speed of 10 r/s from a pulley with a diameter of 600 mm on an electrical motor which rotates at 7,2 r/s. (FIGURE 2.3 below.) The maximum acceptable tensile force in the available belt is 300 N.

Determine the power in kW, which can be transmitted by the belt drive, if the ratio of the tensile force in the tight side to the tensile force in the slack side is 2,5 : 1.

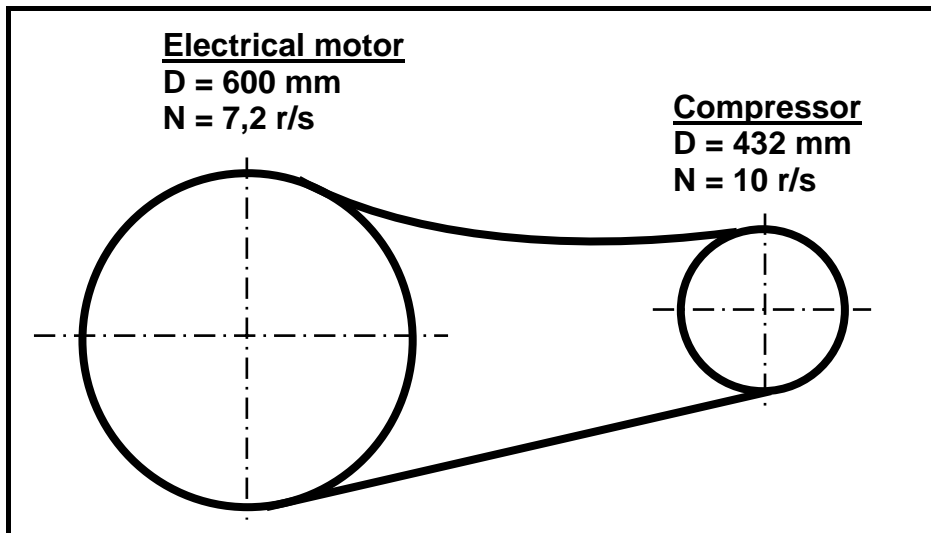
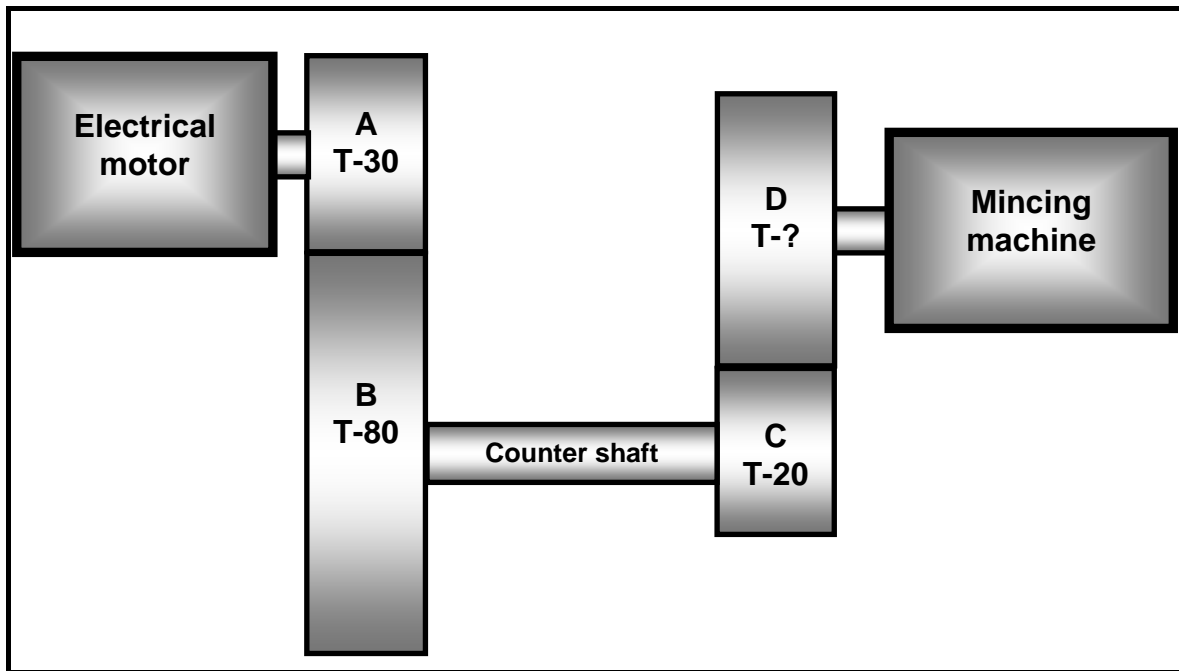


FIGURE 2.3

(7)

2.4 Study FIGURE 2.4 below. Lukas is the engineer who must design a gear drive for a mincing machine. The shaft of the mincing machine must rotate at 90 r/min. The rest of the gear drive is as follows:

On the electrical motor there is a driver gear A with 30 teeth, rotating at 480 r/min, that meshes in with a driven gear B with 80 teeth on a counter shaft. On the countershaft there is a second driver gear C with 20 teeth that meshes in with the final driven gear D.

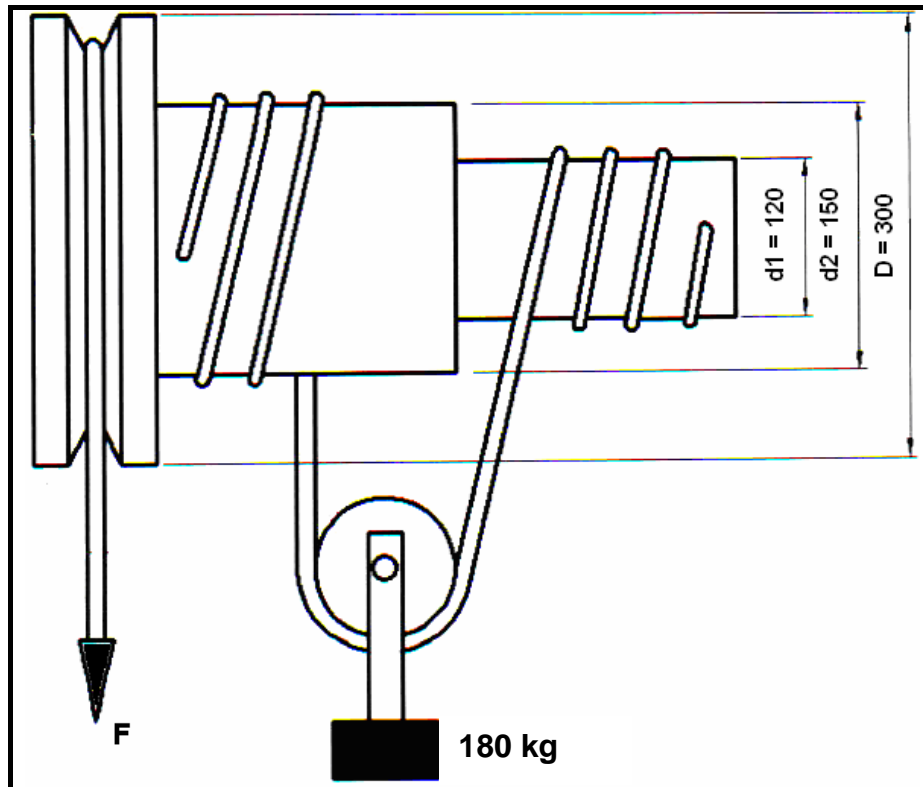


**FIGURE 2.4**

Determine, by means of calculations, the following:

- 2.4.1 The number of teeth on the final driven gear D (4)
- 2.4.2 The gear ratio of the system (3)

2.5 Study FIGURE 2.5 below. A differential wheel and axle lifting machine is used to lift an engine with a mass of 180 kg. The diameter of the wheel **D** is 300 mm and the diameters of the axles **d2** and **d1** are 150 mm and 120 mm respectively. The effort **F**, needed for this load, is 100 N.



**FIGURE 2.5**

Determine, by means of calculations, the following:

- 2.5.1 The mechanical advantage of the appliance (3)
- 2.5.2 The velocity ratio (2)
- 2.5.3 The mechanical efficiency of this machine at this load (2)

2.6 A single-plate friction clutch with an effective diameter of 250 mm is used to transmit torque in the final drive. The clutch plate has friction material on both sides. The friction coefficient is 0,4. The total force applied on the pressure plate is 3 kN.

Determine, by means of calculations, the following:

- 2.6.1 The torque that can be transmitted by this clutch (3)
- 2.6.2 The power transmitted at 3 000 r/min (2)

**[50]**

**QUESTION 3: TOOLS AND EQUIPMENT**

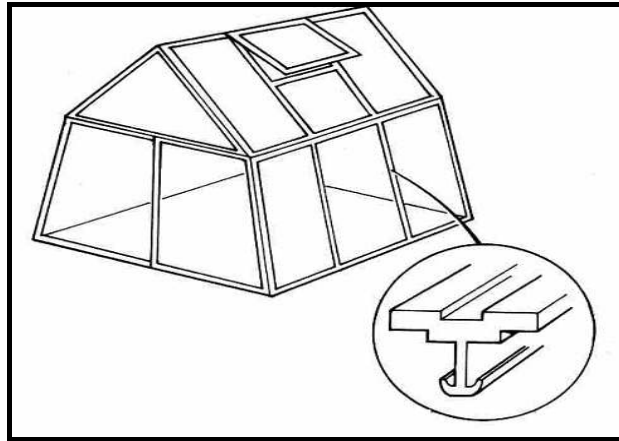
- 3.1 Explain how a voltmeter and an ammeter are connected to a circuit. (2)
- 3.2 What does the abbreviation *MAGS/MIGS* stand for in terms of welding equipment? (2)
- 3.3 State TWO uses of the multi-meter. (2)
- 3.4 Read the scenario below and answer the questions that follow.

Mrs Gogo Xuma uses her car daily from her home to Durban and back. She covers a distance of 42 km daily. Recently she discovered that her car is losing power. She asks Mr Manzi to assist her to find out why her car is losing power. Mr Manzi did a compression test on her car.

- 3.4.1 Give FOUR reasons for a compression test. (4)
- 3.4.2 Explain the procedure to carry out a dry compression test. (10)
- [20]**

**QUESTION 4: MATERIALS**

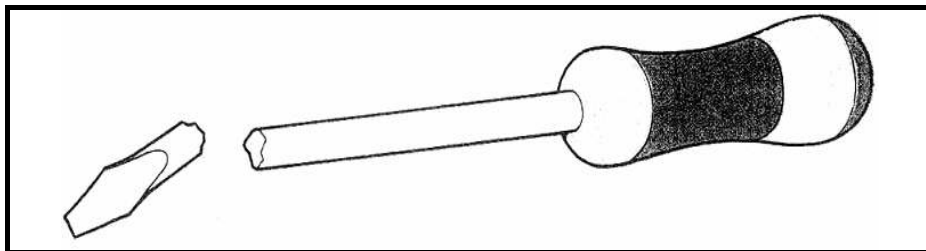
- 4.1 Some structural frames are assembled from stainless steel sections as shown in FIGURE 4.1 below. Which TWO properties of stainless steel make it unnecessary for the frame to be painted?



**FIGURE 4.1**

(2)

- 4.2 The screw driver shown in FIGURE 4.2 below snapped during use. Explain why the screw driver snapped by referring to the properties of materials. Give a reason for your answer.



**FIGURE 4.2**

(2)



- 4.3 Two test pieces, A and B, are tested for their toughness as shown in FIGURE 4.3 below. After a single hammer blow test piece A broke from hammer position 1. Test piece B only broke after the hammer was moved to position 2. Refer to the hammer position and explain which one is the toughest.

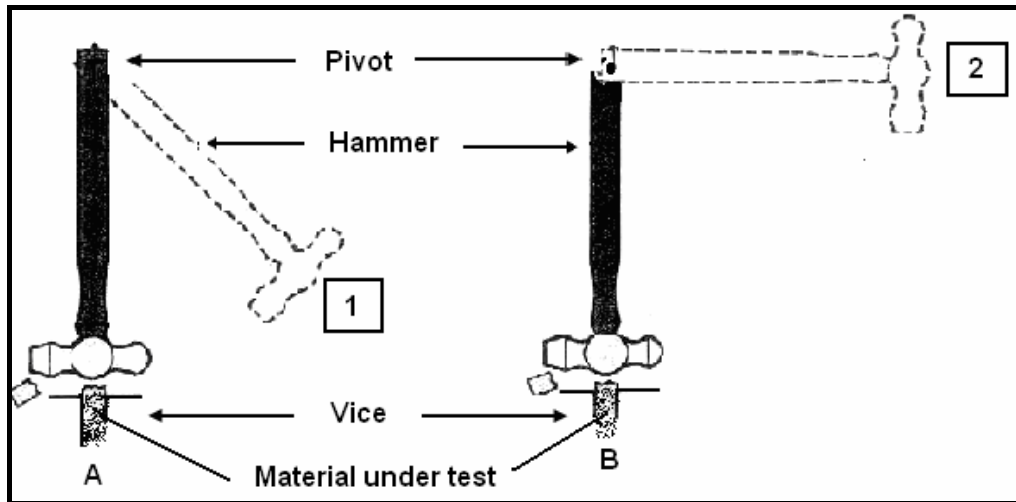


FIGURE 4.3

(4)

- 4.4 Electrical cable is made by extruding a plastic coat onto copper wire as shown in FIGURE 4.4 below. Name TWO plastics which are used for this purpose and also give ONE reason for the suitability of each.

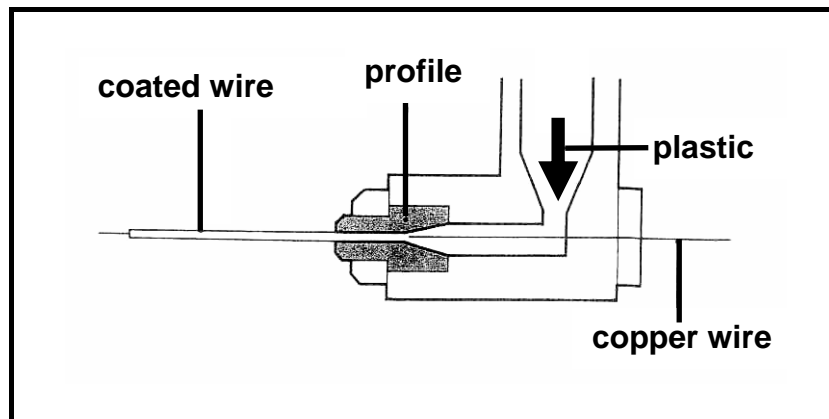


FIGURE 4.4

(4)

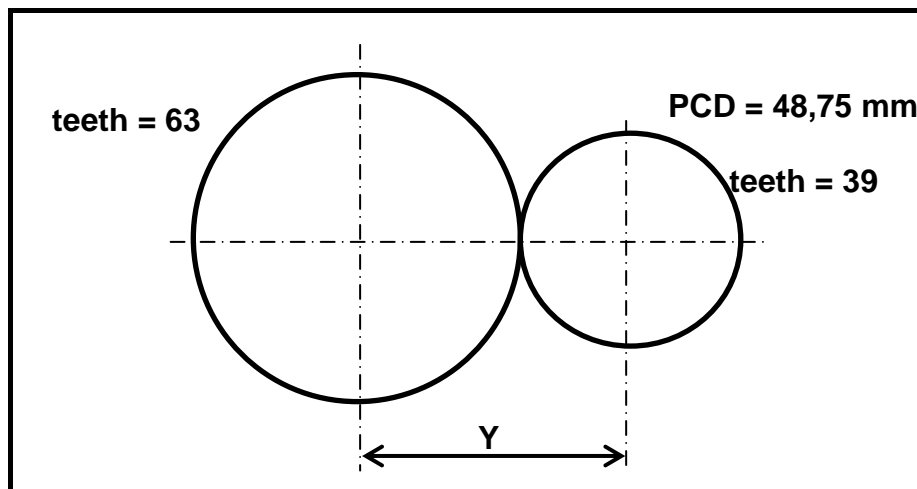
- 4.5 What is understood by the term *non-ferrous alloy*? Give ONE example of a non-ferrous alloy. (2)
- 4.6 State TWO differences between *silver soldering* and *brazing* (hard soldering) in terms of composition and uses. Draw a table to show the differences. (4)
- 4.7 Name ONE of the carbon steels and state its carbon content as a percentage. (2)

[20]

**QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS**

- 5.1 Mary uses a beam bending tester to test a work piece to determine its degree of deflection. State FOUR safety precautions to be taken when using the beam bending tester. (4)
- 5.2 Johannes cuts a solid diameter 25 mm mild steel shaft on a centre lathe. The working environment of the centre lathe must be kept in a good condition. What FOUR safety precautions must Johannes consider **before** working on a centre lathe? (4)
- 5.3 Give the reason why oil and grease should not be in contact with oxy-acetylene regulators. (2)
- 5.4 Name FOUR methods of indexing that can be used on the universal dividing head of a milling machine. (4)
- 5.5 Before Willy uses the milling machine, he needs to calculate the feed first. Use the following information to calculate the feed in mm/min. (Hint: First calculate N.) (6)
- Diameter of cutter = 100 mm  
Number of teeth = 24  
Cutting speed = 40 m/min  
Feed per tooth = 0,09 mm per tooth

- 5.6 FIGURE 5.1 below shows two spur gears that mesh with each other. Use the information shown on the sketch and calculate the following:



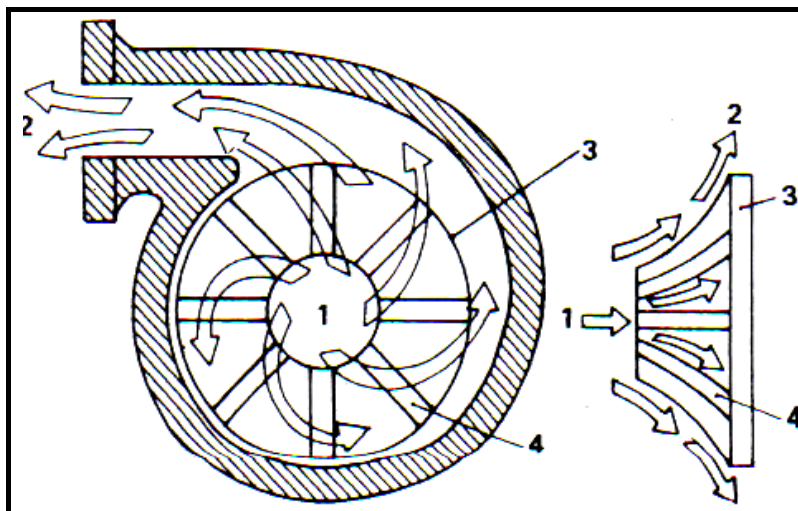
**FIGURE 5.1**

- 5.6.1 The module of the small gear (2)
- 5.6.2 The outside diameter of the big gear (2)
- 5.6.3 The PCD of the big gear (2)
- 5.6.4 The dedendum of the big gear (2)
- 5.6.5 The centre distance between the two gears (distance Y) (3)
- 5.7 When mild steel is welded with arc welding certain welding defects can occur. Name TWO possible causes and ONE prevention method for each of the following welding defects:
- 5.7.1 Cracks (3)
- 5.7.2 Slag inclusion (3)
- 5.8 Name THREE non-destructive tests that can be done on mild steel. (3)
- 5.9 Jan is an artisan who has to mill a spur gear with 63 teeth. The dividing head ratio is 40 : 1. (Hint: Use 60 divisions for the indexing.)
- 5.9.1 Calculate the indexing that is required. (4)
- 5.9.2 Calculate the change gears that are required. (4)
- 5.9.3 Determine the direction of rotation of the index plate in relation to the index crank. (2)

**[50]**

**QUESTION 6: MAINTENANCE AND TURBINES**

- 6.1 You are instructed to machine a work piece using the milling machine. One of the requirements is that you use a cutting fluid to ensure that it keeps the work piece cool. Give FOUR other reasons for using a cutting fluid. (4)
- 6.2 Most car manufacturers recommend that their cars be serviced at a 10 000 km or 15 000 km intervals. Answer the questions that follow.
- 6.2.1 State THREE functions of engine oil. (3)
- 6.2.2 Explain the procedure to change the oil in the differential of a rear wheel drive motor car. (13)
- 6.3 A blower can be fitted to the engine to increase the vehicle's engine performance as shown in FIGURE 6.1 below. Answer the questions that follow.



**FIGURE 6.1**

- 6.3.1 Identify the type of blower shown in FIGURE 6.1. (1)
- 6.3.2 Label the parts numbered 1 to 4. (4)
- 6.3.3 Explain the operation of the above blower. (5)
- 6.4 Most modern cars make use of superchargers. Answer the following questions.
- 6.4.1 State THREE advantages of a supercharger. (3)
- 6.4.2 State THREE disadvantages of a supercharger. (3)

- 6.5 State the function of the steam turbine. (2)
- 6.6 State TWO uses of the steam turbine. (2)
- [40]**
- TOTAL: 200**

**FORMULA SHEET FOR MECHANICAL TECHNOLOGY – GRADE 12****1. BELT DRIVES**

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

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

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

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

$$1.5 \quad N_1 D_1 = N_2 D_2$$

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

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

$$1.8 \quad \text{Power} = \frac{2 \pi N T}{60}$$

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

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

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

**2. FRICTION CLUTCHES**

$$2.1 \quad \text{Torque } (T) = \mu W n R$$

$\mu = \text{coefficient of friction}$   
 $W = \text{total force}$   
 $n = \text{number of friction surfaces}$   
 $R = \text{effective radius}$

$$2.2 \quad \text{Power} = \frac{2 \pi N T}{60}$$

**3. STRESS AND STRAIN**

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

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

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

$$3.4 \quad A_{\text{shaft}} = \frac{\pi d^2}{4}$$

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

**4. HYDRAULICS**

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

$$4.2 \quad \text{Volume} = \text{Cross-sectional area} \times \text{stroke length} (l \text{ or } s)$$

$$4.3 \quad \text{Work done} = \text{force} \times \text{distance}$$

**5. WHEEL AND AXLE**

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

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

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

**6. LEVERS**

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

$$6.2 \quad \text{Input movement} (IM) = \text{Effort} \times \text{distance moved by effort}$$

$$6.3 \quad \text{Output movement} (OM) = \text{Load} \times \text{distance moved by load}$$

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

**7. GEAR DRIVES**

$$7.1 \quad \text{Power} = \frac{2 \pi NT}{60}$$

$$7.2 \quad \text{Gear ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$7.3 \quad \frac{N_{\text{input}}}{N_{\text{output}}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$7.4 \quad \text{Torque} = \text{force} \times \text{radius}$$

$$7.5 \quad \text{Torque transmitted} = \text{gear ratio} \times \text{input torque}$$

$$7.6 \quad \text{Module (m)} = \frac{\text{Pitch-circle diameter (PCD)}}{\text{Number of teeth (T)}}$$

$$7.7 \quad N_1 T_1 = N_2 T_2$$

$$7.8 \quad \text{Pitch-circle diameter (PCD)} = \frac{\text{circular pitch (CP)} \times \text{number of teeth (T)}}{\pi}$$

$$7.9 \quad \text{Outside diameter (OD)} = \text{PCD} + 2 \text{ module}$$

$$7.10 \quad \text{Addendum (a)} = \text{module (m)}$$

$$7.11 \quad \text{Dedendum (b)} = 1,157 m \quad \text{or} \quad \text{Dedendum (b)} = 1,25 m$$

$$7.12 \quad \text{Cutting depth (h)} = 2,157 m \quad \text{or} \quad \text{Cutting depth (h)} = 2,25 m$$

$$7.13 \quad \text{Clearance (c)} = 0,157 m \quad \text{or} \quad \text{Clearance (c)} = 0,25 m$$

$$7.14 \quad \text{Circular pitch (CP)} = m \times \pi$$



**8. SCREW THREADS**

$$8.1 \quad \text{Pitch diameter} = \text{Outside diameter} - \frac{1}{2} \text{ pitch}$$

$$8.2 \quad \text{Pitch circumference} = \pi \times \text{pitch diameter}$$

$$8.3 \quad \text{Lead} = \text{pitch} \times \text{number of starts}$$

$$8.4 \quad \text{Helix angle: } \tan \theta = \frac{\text{Lead}}{\text{Pitch circumference}}$$

$$8.5 \quad \text{Leading tool angle} = 90^\circ - (\text{helix angle} + \text{clearance angle})$$

$$8.6 \quad \text{Following/Trailing angle} = 90^\circ + (\text{helix angle} - \text{clearance angle})$$

$$8.7 \quad \text{Number of turns} = \frac{\text{height}}{\text{lead}}$$

**9. CINCINNATI DIVIDING HEAD TABLE FOR THE MILLING MACHINE**

<i>Hole circles</i>											
<i>Side 1</i>	24	25	28	30	34	37	38	39	41	42	43
<i>Side 2</i>	46	47	49	51	53	54	57	58	59	62	66

<i>Standard change gears</i>										
24 x 2	28	32	40	44	48	56	64	72	86	100

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

$$9.2 \quad \text{Change gears: } \frac{Dr}{Dv} = (A - n) \times \frac{40}{A} \quad \text{or} \quad \frac{Dr}{Dv} = \frac{(A - n)}{A} \times \frac{40}{1}$$

or

$$\frac{Dr}{Dv} = (N - n) \times \frac{40}{N}$$

**10. CALCULATIONS OF FEED**

$$10.1 \quad \text{Feed } (f) = f_1 \times T \times N$$

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

$$10.2 \quad \text{Cutting speed } (V) = \pi \times D \times N$$

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

\*\*\*\*\*



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY**

**NOVEMBER 2010**

**MEMORANDUM**

**MARKS: 200**

**This memorandum consists of 18 pages.**

**QUESTION 1: MULTIPLE CHOICE QUESTIONS**

- 1.1 D ✓ (1)
- 1.2 C ✓ (1)
- 1.3 B ✓ (1)
- 1.4 D ✓ (1)
- 1.5 D ✓ (1)
- 1.6 B ✓ (1)
- 1.7 C ✓ (1)
- 1.8 A ✓ (1)
- 1.9 D ✓ (1)
- 1.10 B ✓ (1)
- 1.11 D ✓ C (1)
- 1.12 D ✓ (1)
- 1.13 D ✓ (1)
- 1.14 A ✓ (1)
- 1.15 D ✓ (1)
- 1.16 B ✓ (1)
- 1.17 B ✓ (1)
- 1.18 C ✓ (1)
- 1.19 A ✓ (1)
- 1.20 B ✓ (1)

**[20]**

**QUESTION 2: FORCES, SYSTEMS AND CONTROL****2.1 HYDRAULICS****2.1.1 Calculate the fluid pressure in the system:**

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

$$= \frac{\pi(0.1)^2}{4} \quad \checkmark$$

$$= 7,85 \times 10^{-3} \text{ m}^2$$

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

$$= \frac{150 \times 10^3}{7,85 \times 10^{-3}} \quad \checkmark$$

$$= 19,108 \text{ MPa}$$

$$= 19,11 \text{ MPa} \quad \checkmark \quad (4)$$

**2.1.2 Calculate the force on piston A:**

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

$$= \frac{\pi(0,025)^2}{4} \quad \checkmark$$

$$= 0,49 \times 10^{-3} \text{ m}^2$$

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

$$= \frac{150 \times 10^3}{7,85 \times 10^{-3}} \times 0,49 \times 10^{-3} \quad \checkmark$$

$$= 9363,9 \text{ N}$$

$$= 9,36 \text{ kN} \quad \checkmark \quad (4)$$

**2.1.3 Calculate force F:**

$$F \times 0,48 = 9363,9 \times 0,08 \quad \checkmark \checkmark$$

$$F = \frac{9363,9 \times 0,08}{0,48} \quad \checkmark$$

$$= 1560,65 \text{ N} \quad \checkmark \quad (4)$$

**2.2 STRESS AND STRAIN****2.2.1 Calculate the maximum stress in part C:**

$$\begin{aligned}
 A_C &= \frac{\pi D^2}{4} && \checkmark \\
 &= \frac{\pi(0,05)^2}{4} && \checkmark \\
 &= 1,96 \times 10^{-3} \text{ m}^2 && \checkmark \\
 \\ 
 \sigma_C &= \frac{F}{A_C} && \checkmark \\
 &= \frac{12 \times 10^3}{1,96 \times 10^{-3}} \\
 &= 6,12 \times 10^6 \text{ Pa} \\
 &= 6,12 \text{ MPa} && \checkmark \quad (5)
 \end{aligned}$$

**2.2.2 Calculate the strain in part A:**

$$\begin{aligned}
 E &= \frac{\sigma_A}{\varepsilon_A} \\
 \varepsilon_A &= \frac{\sigma_A}{E} && \checkmark \\
 \text{BUT} \\
 \sigma_A &= \frac{F}{A_A} && \checkmark \\
 \sigma_A &= \frac{F \times 4}{\pi(D_A)^2} && \checkmark \\
 &= \frac{12 \times 10^3 \times 4}{\pi(0,1)^2} && \checkmark \\
 &= 1,527 \times 10^6 \text{ Pa} && \checkmark \\
 &= 1,53 \text{ MPa} \\
 \\ 
 \varepsilon_A &= \frac{\sigma_A}{E} && \checkmark \\
 &= \frac{1,53 \times 10^6}{108 \times 10^9} \\
 &= 0,014 \times 10^{-3} \quad \text{or} \quad 0.00001414 && \checkmark \quad (7)
 \end{aligned}$$

**ALTERNATIVELY****2.2.2 Calculate the strain in part A:**

$$\begin{aligned}\sigma_A \times A_A &= \sigma_C \times A_C && \checkmark \\ \sigma_A &= \frac{\sigma_C \times A_C}{A_A} && \\ \sigma_A &= \frac{\sigma_C \times (D_C)^2}{(D_A)^2} && \checkmark \\ &= \frac{\sigma_C \times (50)^2}{(100)^2} && \checkmark \\ &= \frac{\sigma_C}{2^2} && \\ &= \frac{6,12 \times 10^6}{4} && \checkmark \\ \sigma_A &= 1,53 \times 10^6 \text{ Pa} && \checkmark \\ \varepsilon_A &= \frac{\sigma_A}{E} && \\ &= \frac{1,53 \times 10^6}{108 \times 10^9} && \checkmark \\ &= 0,014 \times 10^{-3} && \checkmark \quad (7)\end{aligned}$$

**2.3 BELT DRIVE****Calculate power transmitted:**

$$\frac{T_1}{T_2} = 2,5$$

$$T_2 = \frac{T_1}{2,5}$$

$$= \frac{300}{2,5}$$

$$T_2 = 120 \text{ N}$$

$$P = (T_1 - T_2)\pi Dn$$

$$= (300 - 120) \times \pi \times 0,6 \times 7,2$$

$$= 2442,9 \text{ Watt}$$

$$= 2,44 \text{ kW}$$

OR

$$P = (T_1 - T_2)\pi Dn$$

$$= (300 - 120)\pi \times 0,432 \times 10$$

$$= 2442,9 \text{ Watt}$$

$$= 2,44 \text{ kW}$$

√

√

√

√

√√

√

**O****R**

√

√√

√

(7)

**2.4 GEAR DRIVE****2.4.1 Calculate the number of teeth on the final gear D:**

$$\frac{\text{Product of number of teeth on driven gears}}{\text{Product of number of teeth on driver gears}} = \frac{N_{DR}}{N_{DN}}$$

$$\frac{80 \times T_D}{30 \times 20} = \frac{480}{90}$$

$$T_D = \frac{480 \times 30 \times 20}{90 \times 80}$$

$$= 40 \text{ Teeth}$$

√

√

√

√

(4)



**2.4.2 The gear ratio of the system:**

$$\begin{aligned}
 \text{Gear ratio} &= \frac{\text{Product of number of teeth on driven gears}}{\text{Product of number of teeth on driver gears}} && \checkmark \\
 &= \frac{80 \times 40}{30 \times 20} && \checkmark \\
 &= 5,3 : 1 && \checkmark \\
 &\text{OR} && \checkmark \\
 \text{Gear ratio} &= \frac{N_{\text{input}}}{N_{\text{output}}} && \mathbf{O} \\
 &= \frac{480}{90} && \mathbf{R} \\
 &= 5,3 : 1 && \checkmark \quad (3)
 \end{aligned}$$

**2.5 WHEEL AND AXLE****2.5.1 Calculate the mechanical advantage of the system:**

$$\begin{aligned}
 MA &= \frac{\text{Load}}{\text{Effort}} && \checkmark \\
 &= \frac{1800}{100} && \checkmark \\
 &= 18 && \checkmark \quad (3)
 \end{aligned}$$

**2.5.2 Calculate the velocity ratio of the system:**

$$\begin{aligned}
 VR &= \frac{2D}{d_2 - d_1} && \checkmark \\
 &= \frac{2 \times 0,3}{0,15 - 0,12} \quad \text{or} \quad VR = \frac{600}{30} && \\
 &= 20 : 1 && \checkmark \quad (2)
 \end{aligned}$$

**2.5.3 Calculate the mechanical efficiency of the system:**

$$\begin{aligned}
 \eta &= \frac{MA}{VR} \times 100 && \\
 &= \frac{18}{20} \times 100 && \checkmark \\
 &= 90\% && \checkmark \quad (2)
 \end{aligned}$$

**2.6 CLUTCH****2.6.1 Calculate the torque transmitted by the clutch:**

$$\begin{aligned} T &= \mu W n R && \checkmark \\ &= 0,4 \times 3 \times 10^3 \times 2 \times \left( \frac{0,25}{2} \right) && \checkmark \\ &= 300 Nm && \checkmark \quad (3) \end{aligned}$$

**2.6.2 Calculate the power transmitted:**

$$\begin{aligned} P &= \frac{2 \pi N T}{60} && \checkmark \\ &= \frac{2 \pi \times 3000 \times 300}{60} \\ &= 94,247 \times 10^3 W \quad \text{or} \quad 94247,78 \text{ Watt} \\ &= 94,25 kW && \checkmark \quad (2) \end{aligned}$$

**[50]**

**QUESTION 3: TOOLS AND EQUIPMENT**

3.1 **VOLTMETER** is connected in parallel with a circuit. ✓  
**AMMETER** is connected in series with a circuit. ✓ (2)

3.2 Metal Arc Gas Shielded/Metal Inert Gas Shielded ✓✓ (2)

3.3 **USES OF A MULTI-METER:**

- Direct current measurement (DC) ✓
- Alternating current measurement (AC) ✓
- Diode and continuity measurement ✓
- Battery measurement ✓
- Resistance measurement ✓
- Temperature measurement ✓
- Transistor test ✓
- Direct current voltage measurement ✓

(Any 2 x 1)

(2)

3.4 **COMPRESSION TEST**

3.4.1 **Reasons for compression test:**

- **Valve clearances** ✓
- Leaking exhaust valve ✓
- Leaking cylinder head gasket ✓
- Worn rings ✓
- Worn cylinders ✓
- Worn piston ✓
- Leaking inlet valve. ✓
- **Loose cylinder head bolt**
- **Cracked cylinder head**
- **Cracked piston**

(Any 4 x 1)

(4)

3.4.2 **Dry compression test:**

- Run engine until normal operating temperature is reached. ✓✓
- Air cleaner to be removed and jam the choke and throttle valve in the open position, to allow maximum air to enter the combustion chamber. ✓✓
- Disconnect the primary coil lead to prevent spark. ✓
- Clean area around spark plug and the screw the pressure gauge into the spark plug hole. ✓✓
- Crank the engine until the gauge stops rising. ✓
- Test all the cylinders and compare the readings to the manufacturer's specifications. ✓✓

(10)  
**[20]**

**QUESTION 4: MATERIALS**

**4.1 PROPERTIES OF STAINLESS STEEL:**

- It has a shiny appearance due to chromium oxide film applied to the surface √
- It has good resistance to corrosion due to a high chrome content. √ (2)

**4.2 SCREW DRIVER:**

Reason: The material is too brittle. √

Support: A brittle material is the one that fractures with little or no deformation √ (2)

**4.3 HAMMER:**

Material B is the toughest. √√

Reason: Toughness is measured by the amount of energy needed to break the material. The higher the swing height of the hammer the higher the toughness of the material. √√ (4)

**4.4 ELECTRICAL CABLE:**

Polyvinylchloride (PVC) and Polythene (Polyethylene) √√

Reasons: They soften on heating and can be moulded into shape. √  
On cooling they harden. √ (4)

**4.5 NON-FERROUS ALLOYS:**

A non-ferrous alloy is a metal that has a combination of two or more non-ferrous metals which are melted together to form one non-ferrous alloy. √

Example: Brass; Bronze; White metal; duralumin and solder (only one example) √ (2)

4.6

Process	Composition	Uses
Silver soldering	They are alloys of copper, zinc and silver, <b>tin and lead</b> <span style="float: right;">√</span>	They are used to produce strong ductile joints in copper, brass and in jewellery work <span style="float: right;">√</span>
Brazing	They make use of zinc copper alloys	They are used to produce strong ductile joints in ferrous metals. <span style="float: right;">√</span>

(4)

**4.7 CARBON STEEL:**

- Low carbon steel – 0,25% carbon or  
 Medium carbon steel – 0,5 % carbon or  
 High carbon steel – 1% carbon Select only ONE answer (2 x 1) (2)

**[20]**

**QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS****5.1 BEAM BENDING TESTER:**

- Make sure the object to be tested is firmly secured ✓
- Make sure that all the holding devices are fitted properly ✓
- Check components of a tester for wear ✓
- Check for leaks at the hydraulic pump ram. ✓
- Make sure the area around tester is clean and free from oil and grease ✓  
(Any 4 x 1) (4)

**5.2 CENTRE LATHE:**

- **Personal safety**
- Do not operate the machine until you are certain you know the procedures ✓
- Make sure that the machine is clean and safe to use ✓
- Clamp work piece firmly/securely ✓
- Choose the correct cutting tool and holding device for the job ✓
- Make sure that all guards are in place before you operate the machine ✓
- Remove the chuck key from the chuck before starting the machine ✓
- Make sure the area around the lathe is free from oil, grease and any scrap metal. ✓  
(Any 4 x 1) (4)

5.3 **OIL AND GREASE** are highly flammable under high pressure in the presence of oxygen. ✓ (2)

**5.4 METHODS OF INDEXING:**

- Direct indexing/Rapid indexing ✓
- Simple indexing ✓
- Angular indexing ✓
- Differential indexing ✓ (4)

**5.5 FEED IN MILLIMETRE PER MINUTE:**

$$\begin{aligned}
 D &= \frac{100}{1000} && \checkmark \\
 &= 0,1m && \\
 v &= \pi DN && \\
 N &= \frac{v}{\pi D} && \checkmark \\
 &= \frac{40}{\pi \times 0,1} && \checkmark \\
 &= 127,32 \text{ r/min} && \checkmark \\
 \text{feed} &= f_1 \times T \times N && \checkmark \\
 &= 0,09 \times 24 \times 127,32 && \\
 &= 275,01 \text{ mm/min} && \checkmark \quad (6)
 \end{aligned}$$

**5.6 GEARS****5.6.1 Calculate the module of the small gear:**

$$\begin{aligned}
 m &= \frac{PCD}{T} && \\
 &= \frac{48,75}{39} && \checkmark \\
 &= 1,25 \text{ mm} && \checkmark \quad (2)
 \end{aligned}$$

**5.6.2 Calculate the outside diameter of the big gear:**

$$\begin{aligned}
 \text{Outside diameter} &= m(T + 2) && \checkmark \\
 &= 1,25(63 + 2) \text{ or } && \checkmark \quad (2) \\
 &= 81,25 \text{ mm} && \\
 OD &= PCD + 2m && \\
 &= m \times T + 2m && \\
 &= 1,25 \times 63 + 2,5 && \\
 &= 78,75 + 2,5 && \\
 &= 81,25 \text{ mm} &&
 \end{aligned}$$

**5.6.3 Calculate the PCD of the big gear:**

$$\begin{aligned}
 PCD &= m \times T && \checkmark \\
 &= 1,25 \times 63 && \checkmark \quad (2) \\
 &= 78,75 \text{ mm} &&
 \end{aligned}$$

**5.6.4 Calculate the dedendum of the big gear:**

$$\begin{aligned}
 \text{Dedendum} &= 1,157 \times m \\
 &= 1,157 \times 1,25 \\
 &= 1,446 \text{ mm} \\
 &= 1,45 \text{ mm}
 \end{aligned}$$

√  
√ (2)

*OR*

$$\begin{aligned}
 \text{Dedendum} &= 1,25 \times m \\
 &= 1,25 \times 1,25 \\
 &= 1,56 \text{ mm}
 \end{aligned}$$

**O**  
**R**  
√  
√ (2)

**5.6.5 The centre distance Y**

$$\begin{aligned}
 \text{Distance } Y &= \frac{\text{PCD big gear} + \text{PCD small gear}}{2} \\
 &= \frac{78,75 + 48,75}{2} \\
 &= 63,75 \text{ mm}
 \end{aligned}$$

√  
√  
√ (3)

**5.7 WELDING DEFECTS**

**5.7.1 Cracks:**

Causes:

- Atmospheric pollution
  - Wrong welding technique
  - Dirty or wet electrodes / corroded MIG wire
  - Wrong electrode
  - Stressed weld
  - Faulty weld joint preparation
  - Cooling rate too fast
  - Craters present
- √  
√  
√  
√  
√  
√  
√  
√  
(Any 2 x 1) (2)

Corrective measures:

- Use low hydrogen electrode.
  - Increase the temperature of the parts to be welded.
  - Fill craters with welding material.
  - Use the correct welding current settings.
- √  
√  
√  
√  
(Any 1 x 1) (1)

5.7.2 **Slag inclusion:**

Causes:

- Rapid chilling √
  - Repeating a weld without removing the previous slag √
  - Weld temperature is too low √
  - High viscosity of the molten metal √
  - Included angle is too small √
- (Any 2 x 1) (2)

Corrective measures:

- Remove slag from the previous weld run. √
  - Increase the preparation angle. √
- (Any 1 x 1) (1)

5.8 **NON-DESTRUCTIVE TESTS:**

- Liquid dye penetrant √
  - Ultrasonic √
  - X-ray √
  - Sound test √
  - Hardness test √
  - Visual inspection √
- (Any 3 x 1) (3)

5.9 **INDEXING**

5.9.1 **Calculate the required indexing:**

$$\begin{aligned}
 \text{Indexing} &= \frac{40}{n} \\
 &= \frac{40}{60} && \sqrt{} \\
 &= \frac{2}{3} \\
 &= \frac{2}{3} \times \frac{8}{8} && \sqrt{} \\
 &= \frac{16}{24} \\
 \text{No full turns, and 16 holes on the 24 hole circle} &&& \sqrt{\sqrt{}} \quad (4)
 \end{aligned}$$

**Other hole circles can also be allowed**



## 5.9.2 Calculate the required change gears:

$$\begin{aligned} \frac{Dr}{Dv} &= (A-n) \times \frac{40}{A} \\ &= (60-63) \times \frac{40}{60} & \text{OR } &= \frac{-120}{60} \\ &= -\frac{3 \times 2}{3} & &= \frac{-2}{1} & \checkmark \\ &= \frac{-2}{1} \times \frac{24}{24} & &= \frac{-2}{1} \times \frac{24}{24} & \checkmark \\ &= \frac{-48}{24} & &= \frac{-48}{24} \\ & \text{Drive gears has 48 teeth and Driven gear has 24} & & & \checkmark\checkmark \quad (4) \end{aligned}$$

## 5.9.3 Direction of rotation of the index plate in relation to the index crank:

The index plate rotates in the opposite direction of the crank. (- sign)  $\checkmark\checkmark$  (2)

**Anti clockwise or left**

**[50]**

**QUESTION 6: MAINTENANCE AND TURBINES**

**6.1 CUTTING FLUIDS:**

- Carry away the heat generated by machining process. ✓
  - Acts as a lubricant. ✓
  - Prevents the chips/swarf from sticking and fusing to the cutter teeth. ✓
  - Improve quality of the finish of machine surface. ✓
  - To keep the cutting tool cool. ✓
  - To obtain a higher cutting speed. ✓
  - It gives the cutting tool a longer lifespan. ✓
  - Does not rust the machine. ✓
  - Helps to wash away the chips/swarf of the metal being removed from the work piece, thus keeping the cutting edge of the cutting tool clean. ✓
- (Any 4 x 1) (4)

**6.2 VEHICLE SERVICE**

**6.2.1 Functions of an oil:**

- It lubricates ✓
  - Provide cooling and control temperature ✓
  - It acts as a seal ✓
  - Reduce engine noise ✓
  - Prolong engine life ✓
  - It absorbs shocks and vibrations ✓
  - Cleans the inside of the engine ✓
- (Any 3 x 1) (3)

**6.2.2 Draining and filling oil for differential unit:**

- Run the vehicle so that the rear axle oil is warm, so that it drains easily. ✓
  - Keep a drain tray that can hold all the oil at hand. ✓
  - Clean area around the drain and filler plug. ✓
  - Remove filler plug this will allow the oil to flow easily and fast. ✓
  - Remove the drain plug using a correct spanner and allow oil to drain into the tray. ✓
  - Allow all the oil to drain out. ✓
  - Wash the drain and filler plug. ✓
  - Fit new washers to both the drain and filler plugs. ✓
  - Replace the drain plug. ✓
  - Fill oil using oil from a plastic dispenser. ✓
  - Fill the oil until the oil just trickles out of the filler hole. ✓
  - Do not overfill the rear axle because this can cause the side shaft seals to fail ✓
  - Replace filler plug and wipe off surplus oil ✓
- (13)

**6.3 BLOWER**

6.3.1 Centrifugal blower √ (1)

**6.3.2 Components**

- 1. Air inlet √
- 2. Air outlet √
- 3. Impeller √
- 4. Fins √ (4)

**6.3.3 Operation:**

- This blower can be driven mechanically by means of a belt drive from the crank shaft or by means of exhaust gases moving through to the exhaust manifold √
- The shaped fins on the impeller move the air around to the outer edge of the impeller into the housing. √
- In doing so, the moving fins leave a low pressure behind it. √
- Air, under atmospheric pressure, rushes in to fill the low pressure at the centre of the impeller. √
- The impeller rotates so fast that a continuous movement of air is present which now builds up a pressure as it is thrown at the rim of the edge. √ (5)

**6.4 SUPER CHARGER**

**6.4.1 Advantages of a supercharger:**

- More power is obtained compared to an engine with a similar capacity without a supercharger √
- Supercharged engines are more economical per given kilowatt output. √
- Less fuel is used compared to engine mass. √
- Power loss is eliminated above sea level. √

(Any 3 x 1) (3)

6.4.2 **Disadvantages of a supercharger:**

- A small amount of power is lost in order to drive the supercharger because it uses the engine power to drive it ✓
- Higher fuel consumption if the power generated is not fully used, as in the case of passenger vehicles ✓
- Due to the compression of the air this results in an increase in air temperature causing a decrease in the density of the inlet charge. ✓
- The lifespan of the engine is decreased because of higher cylinder pressure, which increases the load on the engine components. ✓

(Any 3 x 1) (3)

6.5 **FUNCTION OF STEAM TURBINE:**

- Steam turbines are operated by using steam that generates kinetic energy ✓
- This generates rotational motion which is mechanical energy. ✓ (2)

6.6 **TURBINE USES:**

- To power generators which generate large amounts of electricity. ✓
- To power ship propulsion. ✓ (2)

**[40]**

**TOTAL: 200**