Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2015

MECHANICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

* M C H T D M *

This question paper consists of 24 pages, including a 3-page formula sheet.

INSTRUCTIONS AND INFORMATION

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

QUESTION	CONTENT COVERED	MARKS	TIME (MINUTES)
1	Multiple-choice questions	20	15 minutes
2	Safety	10	10 minutes
3	Tools and equipment	12	10 minutes
4	Materials	13	10 minutes
5	Terminology (Manufacturing process	30	20 minutes
6	Joining methods	25	25 minutes
7	Forces	30	30 minutes
8	Maintenance	15	15 minutes
9	Systems and control	25	25 minutes
10	Turbines	20	20 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 write only the letter (A−D) next to the question number (1.1–1.20) in the ANSWER BOOK, for example 1.21 D.

1.1 Which ONE of the following safety measures is applicable when using this tester as shown below in FIGURE 1.1?

FIGURE 1.1

A Always wear protective safety glasses, gloves, clothing or gear.
B Lubricate the moving parts while the machine is in motion.
C Place the spring on top of the tester.
D Protective clothing is NOT essential when working with the tester. (1)

1.2 Which of the following safety precautions should be observed during metal arc gas-shielded welding, to prevent fire or explosion from welding sparks?

A Worn cables and loose connections can be used on the machine.
B Always work with the gas cylinder in a horizontal position.
C Keep a fire extinguisher in the welding area.
D Provide flammable shielding to protect others. (1)

1.3 The main reason for performing a Brinell hardness test on engineering materials is to determine the …

A elasticity of the material.
B resistance of the material against dentation.
C corrosion of the material.
D fluidity of the material (1)

1.4 Identify the correct measuring instrument to determine the pith diameter of a screw thread:

A Inside micrometer
B Screw-thread micrometer
C Depth micrometer
D Outside micrometer (1)

1.5 What is the lowest critical temperature for all carbon steels?

A 700 °C – 730 °C
B 800 °C – 830 °C
C 750 °C – 790 °C
D 850 °C – 880 °C (1)

1.6 Which ONE of the following is a characteristic of ferrite?

A Soft coarse grain structure
B Intensely hard and brittle
C Soft and ductile
D Extremely hard, strong and brittle (1)

1.7 Calculate the indexing to mill 25 teeth on a gear, using the Cincinnati dividing head.

A 1 turn and 15 holes in a 25-hole plate
B 2 turns and 5 holes in a 25-hole plate
C 2 turns and 15 holes in a 25-hole plate
D 1 turn and 5 holes in a 25-hole plate (1)

1.8 Determine the thickness of a keyway to be used on a 90 mm shaft.

A 10 mm
B 15 mm
C 22,5 mm
D 60 mm (1)

1.9 Identify the milling cutter in the illustration shown in FIGURE 1.9 below.

FIGURE 1.9

A Gang milling cutter
B Face milling cutter
C Straddle milling cutter
D Side milling cutter (1)

1.10 How will you be able to identify the welding defects, using the liquid dye penetrant test?

A Shown through fluorescent liquids on the surface
B Shown on film
C Shown through high frequency sound waves
D Shown through an X-ray (1)

1.11 The technique used by the ultrasonic sound test is to determine …

A external cracks.
B external flaws.
C internal flaws or surface flaws.
D sub-surface flaws. (1)

1.12 Identify the diagram that represents various forces in the illustration shown in FIGURE 1.12 below.

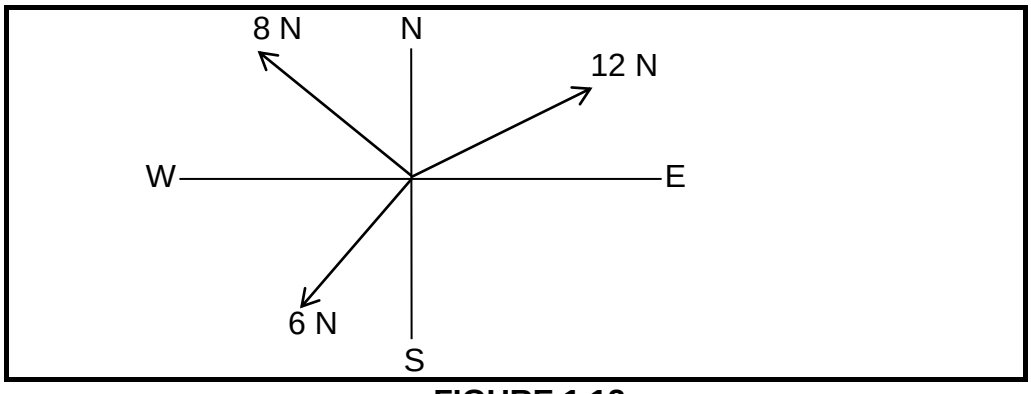


FIGURE 1.12

A Parallelogram of forces
B Polygon of forces
C Moment of forces
D A system of forces (1)

1.13 Young's Modulus of Elasticity may be defined as the …

A internal force which resists a shearing load.
B ratio between the change in length and the original length.
C ratio between the stress and the strain in a metal.
D internal force present in a metal, resisting an external force. (1)

1.14 What maintenance is conducted to keep equipment working or extend the life of the equipment?

A Corrective maintenance
B Predictive maintenance
C Preventative maintenance
D All of the above (1)

1.15 Which statement refers to the viscosity index of oil?

A Viscosity of liquids decreases as temperatures decreases.
B Viscosity of liquids decreases as temperatures increases.
C Viscosity of liquids increases as temperatures increases.
D Viscosity of liquids is not affected by temperature. (1)

1.16 The electrolyte solution in a 12-volt battery is …

A 55% water and 45% sulphuric acid
B 75% sulphuric acid and 25% water
C 25% sulphuric acid and 75% water
D 45% water and 55% sulphuric acid (1)

1.17 Boyle's Law states that the volume of a given mass of gas is inversely proportional to the pressure on it, if the temperature remains constant. Which ONE of the following is correct? The volume of a gas can be changed by altering …

A its pressure.
B its temperature.
C both its temperature and pressure.
D All the above. (1)

1.18 The vehicle management control system/ECU is an electric control unit which can be used to control the following system(s).

A Fuel system
B Ignition system
C Exhaust system
D All of the above. (1)

1.19 Which of the following is an impulse turbine?

A Steam turbine
B Gas turbine
C Pelton water turbine
D Wind turbine (1)

1.20 Which of the following steam turbines are used to generate electricity?

A Condensing turbines
B Reheating turbines
C Extracting turbines
D All of the above. (1)

[20]

QUESTION 2: SAFETY

2.1 State TWO safety rules to be applied before using the Brinell tester, during a destructive test.

(2)

2.2 Mention TWO safety measures to be observed while using a multi-meter.

(2)

2.3 Name TWO safety precautions to consider before working with bearing and gear pullers.

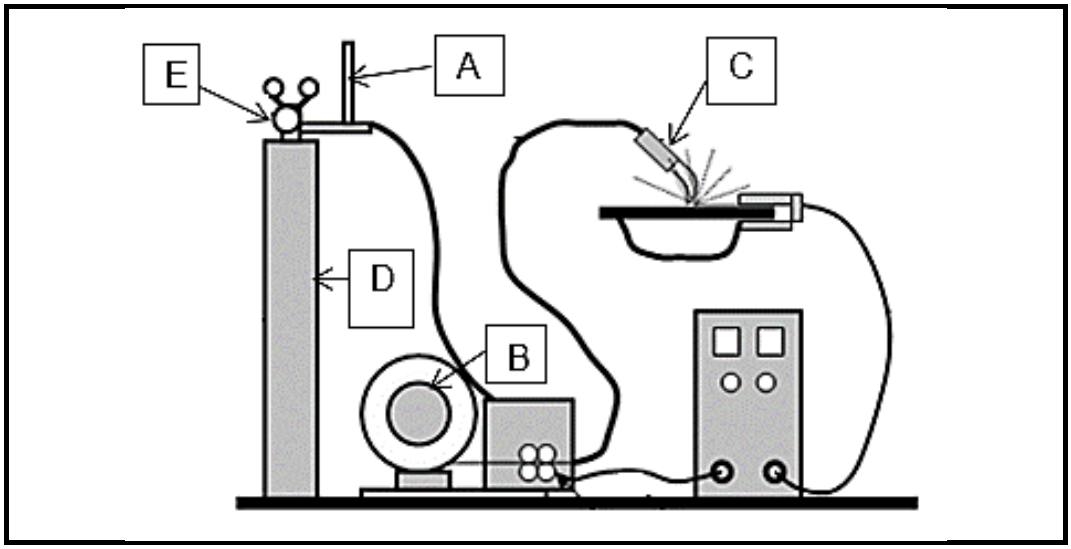
(2)

2.4 State FOUR safety precautions that a welder needs to take into account before using MIG/MAGS equipment. (4)

[10]

QUESTION 3: TOOLS AND EQUIPMENT

3.1 Identify the labels (**A−E**) on the MIG welding machine as shown in FIGURE 3.1 below.

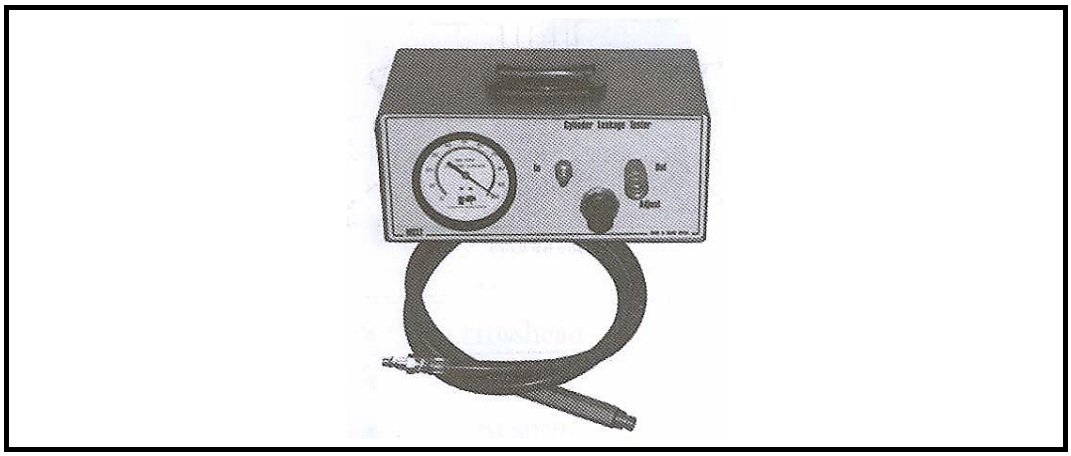


(5)

FIGURE 3.1

3.2 What does the abbreviation MIG stand for in reference to welding equipment? (1)

3.3 Explain the procedure in determining a leak during a cylinder leakage test.



(4)

3.4 Explain the function of a spring tester.

(2)

[12]

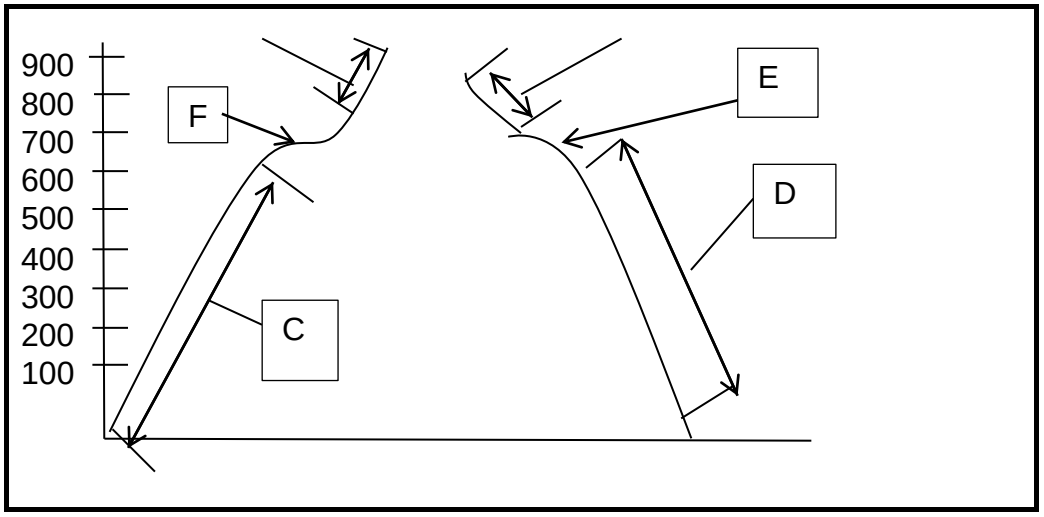
QUESTION 4: MATERIALS

4.1 Complete the following sentence.

Cementite is a compound of … and …, found in steel and cast iron. (2)

4.2 Give ONE characteristic of cementite. (1)

4.3 Identify the labels (**A–E**) on the graph as shown in FIGURE 4.3 below.



(6)

FIGURE 4.3

4.4 Why is vanadium alloyed steel mostly used on forged crankshafts? (1)

4.5 What materials are used in the manufacturing of a camshaft used in an engine?

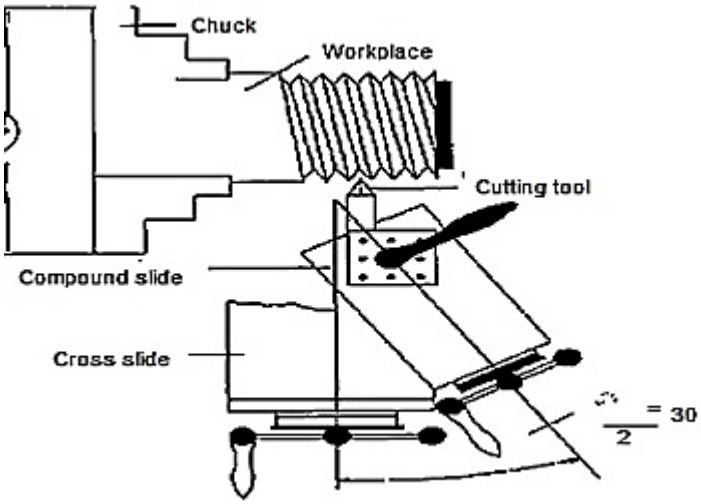
(1)

4.6 Name TWO heat treatment processes that can be performed on medium carbon steel. (2)

[13]

QUESTION 5: TERMINOLOGY

5.1 Explain step by step the cutting procedure of an outside metric V-screw thread, using the cross slide method.



(9)

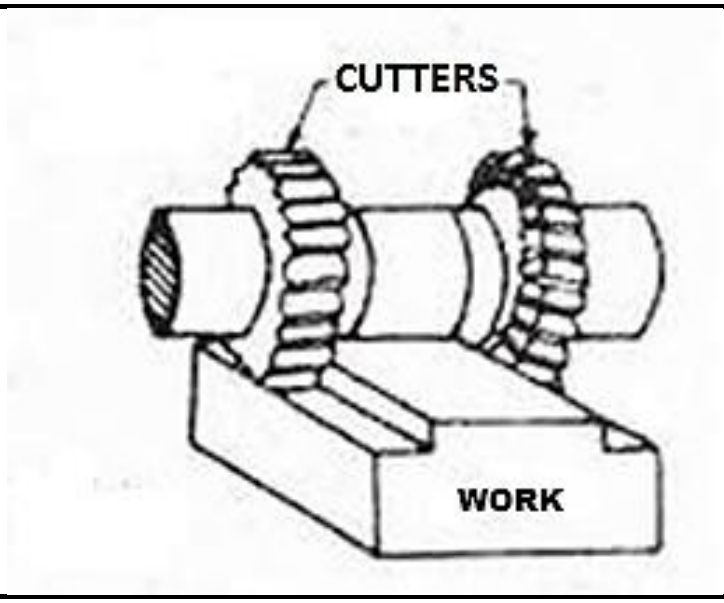
5.2 Calculate the indexing to manufacture a gear with 85 teeth for a gearbox.

Hint: Use 86 divisions for the simple indexing.

5.2.1 Calculate the simple indexing. (2)

5.2.2 Calculate the change gears for the dividing head. (5)

5.3 Explain the *straddle milling operation*.



(4)

5.4 Identify the milling process in FIGURE 5.4 below and explain the process as shown.

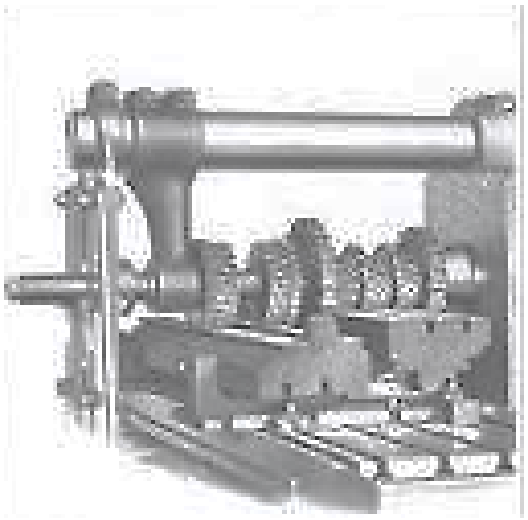


FIGURE 5.4 (4)

5.5 Calculate the indexing for a gear with 114 teeth. (2)

5.6 Identify and name any FOUR main parts of a universal dividing head.

(4)
[30]

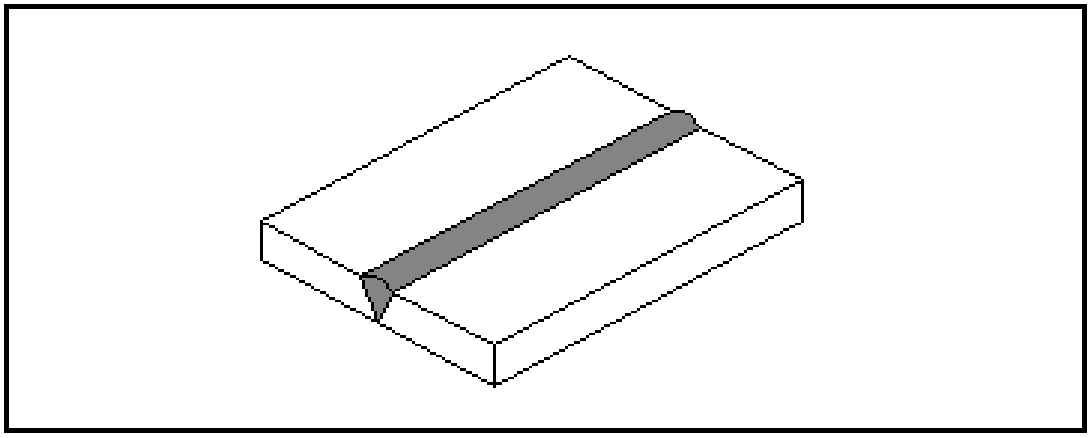
QUESTION 6: JOINING METHODS

6.1 What is the most common application of MIG welding? (1)

6.2 What are the main defects with regard to gas flow problems on MIG welding? (1)

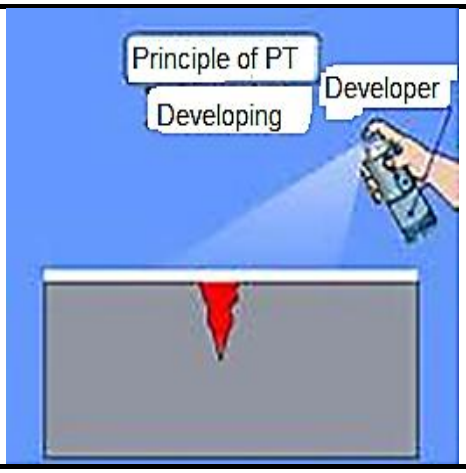
6.3 What is the power source of MIG welding machines? (1)

6.4 Describe how you would apply a nick break test on a butt weld.



(4)

6.5 Explain the application of a non-destructive test using the liquid dye penetrant testing method as used in FIGURE 6.5.



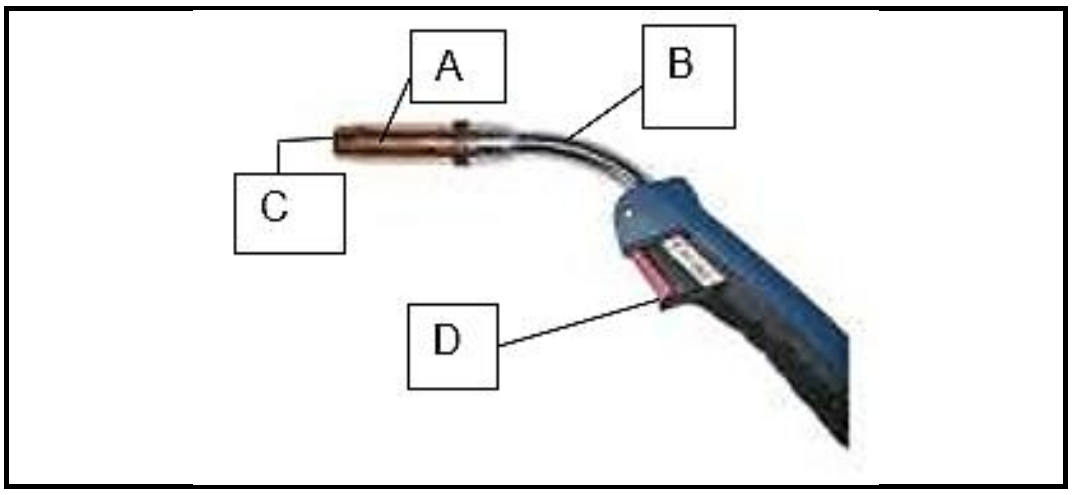
(6)

FIGURE 6.5

6.6 State TWO possible causes for the following welding defects.

	DEFECTS	CAUSES	
6.6.1	Incomplete penetration		(2)
6.6.2	Undercutting		(2)
6.6.3	Slag inclusion		(2)

6.7 Identify the labels (**A−D**) of the MIG welding gun as shown in FIGURE 6.7 below.



(4)

FIGURE 6.7

6.8 What type of shielding gas is used when MIG welding takes place? (1)

6.9 Why is shielding gas used when MIG welding is done? (1)

[25]

QUESTION 7: FORCES

7.1 Peter needs to remove a pin of a yoke from a prop shaft by means of a hydraulic press. FIGURE 7.1 shows the pin that is used to press out the steel pin. The force of 100 kN induces 204 MPa of stress.

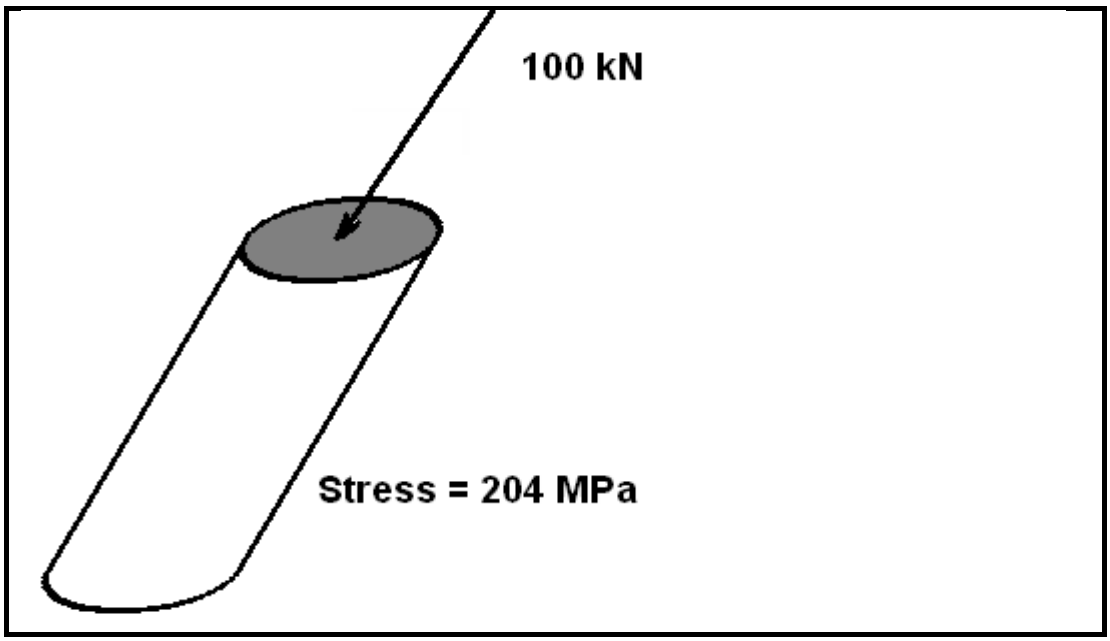


FIGURE 7.1

7.1.1 Calculate the diameter of the pin. (4)

7.1.2 Calculate the strain in the pin when Young's' Modulus of Elasticity is 210 GPa. (3)

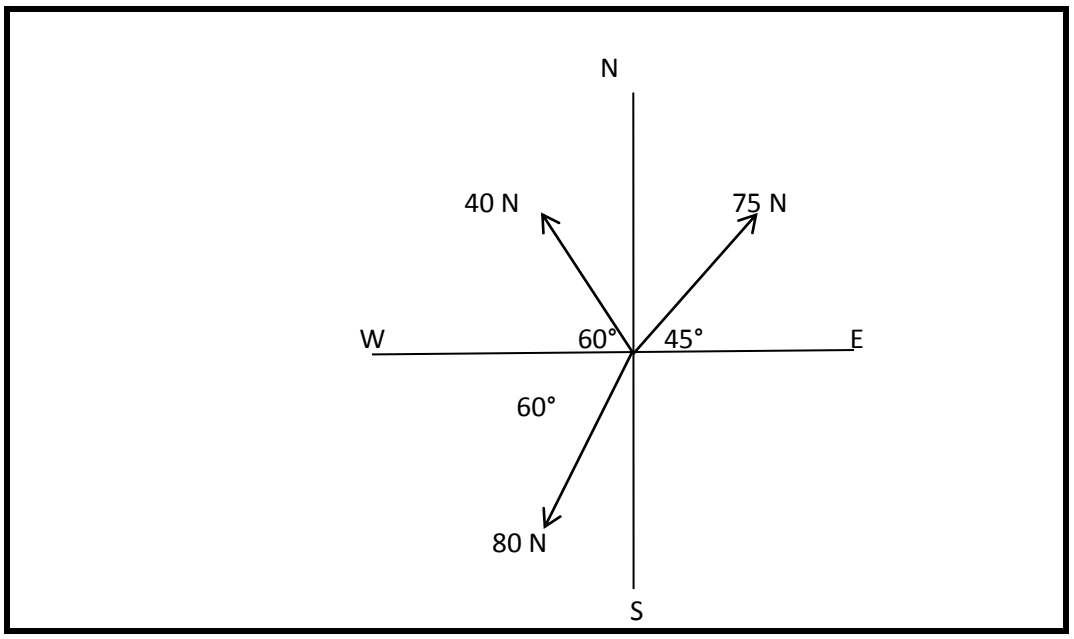
7.1.3 Calculate the change in length of the pin if the original length is 110 mm. (3)

7.1.4 Identify the type of stress in the pin. (1)

7.1.5 What will the influence of the force on the pin be? Motivate your answer with calculations. (2)

7.1.6 If the pin is made from brass, what will the influence on the length of the pin with reference to mild steel be? (3)

7.2 Calculate the resultant force in the system of forces in the illustration below.

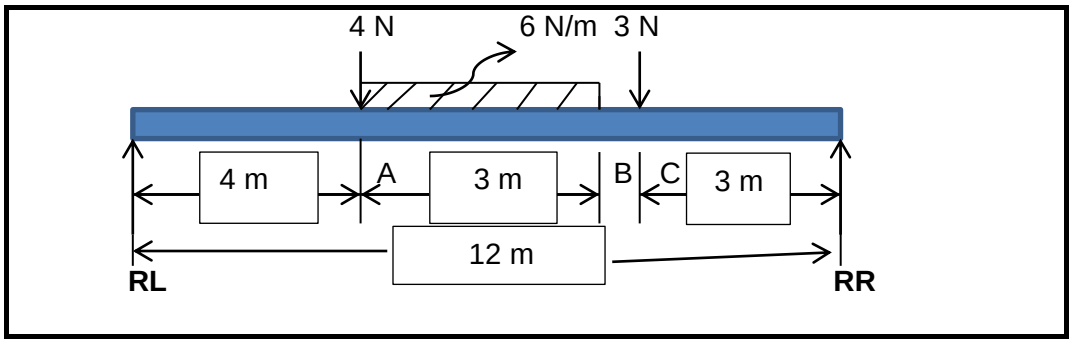


Hint: Use the table below as a guide to add the rectangular components of the forces representing the entire system.

Force	Horizontal component	Magnitude	Vertical component	Magnitude
75 N				
40 N				
80 N				

(6)

7.3 This beam is subjected to a two point load, one UDL and both ends of the beam supported by RL and RR forces.



Calculate:

7.3.1 The magnitude of **RL** and **RR** (4)

7.3.2 The bending moments at points **A**, **B** and **C** (4)

[30]

QUESTION 8: MAINTENANCE

8.1 Name FOUR properties of a good lubricating oil.

(4)

8.2 Give THREE reasons for oil change during maintenance.

(3)

8.3 Explain the application of cutting fluid during the milling process as shown below.

(3)

8.4 Automatic transmission fluids (ATF) are probably the most complex and sophisticated of all lubricating oils. Write down any TWO functions of automatic transmission oil, with examples.

(4)

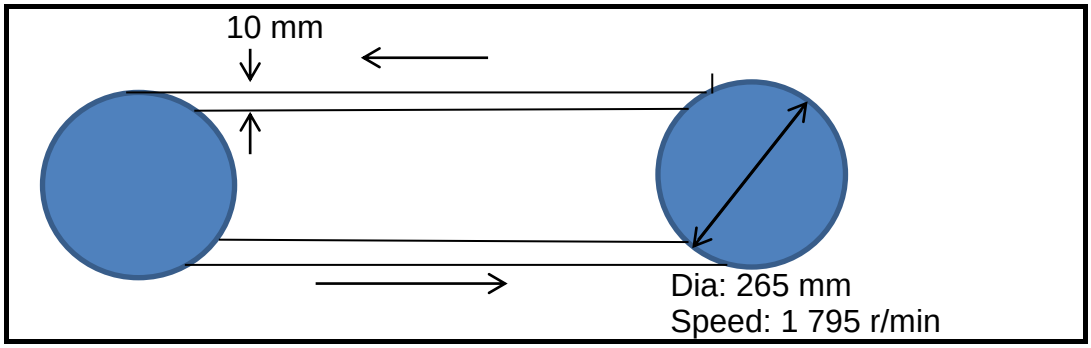
8.5 What does the abbreviation 'EP' in gear oil stand for? (1)

[15]

QUESTION 9: SYSTEMS AND CONTROL

9.1 A fitter and turner is requested to design a flat belt drive system to transport crates of cold drinks from the factory to the warehouse on a conveyor belt. The specifications for the flat belt drive are as follows:

Width of belt: 165 mm
Thickness of belt: 10 mm
Diameter of pulley: 265 mm
Speed of pulley: 1 795 r/min
Density of belt material: 0,75 Mg/m^3



9.1.1 Calculate the mass of the belt in kg/m. (3)

9.1.2 Calculate the belt speed taking the thickness into consideration. (3)

9.1.3 Calculate the required power to drive the belt system if the effective tensile force is 350 N. Ignore the mass of the belt and its friction. (4)

9.2 In a hydraulic press, a force of 600 N is applied to Piston A. Piston A moves 40 mm downwards. The diameter of Piston B is 195 mm and it moves up by 12 mm.

Make use of the specifications in FIGURE 9.2.

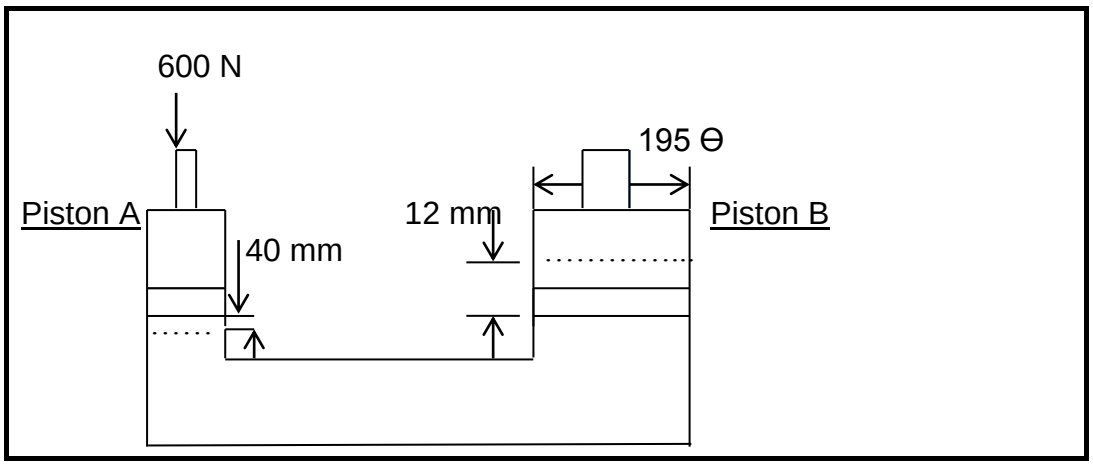


FIGURE 9.2

Hint: $V_A = V_B$

Calculate the following:

9.2.1 The diameter of Piston A (9)

9.2.2 The pressure exerted on Piston A (2)

9.2.3 The force exerted on Piston B (4)

[25]

QUESTION 10: TURBINES

10.1 Identify the TWO categories under which water turbines are classified. (2)

10.2 Which turbine would be used to remove salt from seawater? (1)

10.3 Explain the principle of operation and design of a steam turbine.

(5)

10.4 Explain the operating principle of a water turbine. (3)

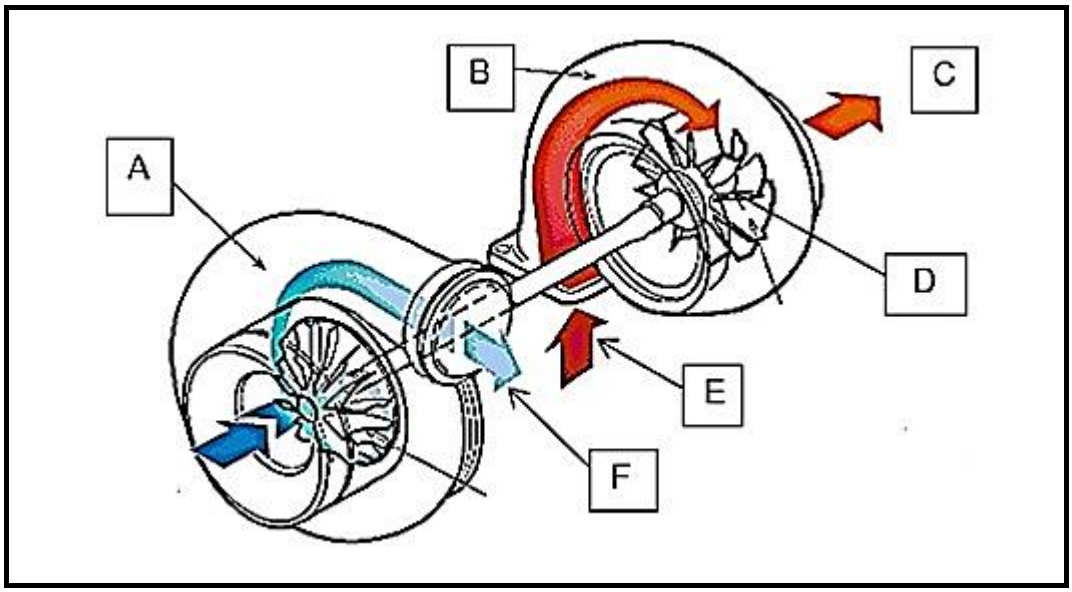
10.5 What is the function of a turbocharger?

(2)

10.6 Name ONE purpose of a supercharger.

(1)

10.7 Identify the parts of the turbocharger as shown below.



(6)
[20]

TOTAL: 200

FORMULA SHEET

1. BELT DRIVES

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

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

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

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

1.5 *Belt length (Flat) = [(D + d) x 1,57] + (2 x centre distance)*

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* $= \frac{T_1}{Permissible\ tensile\ force}$

1.12 *Torque = Force x radius*

2. STRESS AND STRAIN

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

2.2 *Strain* $= \frac{Change\ in\ length}{Original\ length}$

2.3 *Young's modulus (E)* $= \frac{Stress}{Strain}$ *of* $(\frac{\sigma}{\varepsilon})$

3. HYDRAULICS

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

3.2 *Volume = Cross sectional area x stroke length (l or s)*

3.3 *Work done = Force x Distance*

3.4 $P_1 \times V_1 = P_2 \times V_2$

4. GEAR DRIVES

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

4.2 *Gear ratio =* $\frac{Number\ of\ teeth\ on\ driven\ gear}{Number\ of\ teeth\ on\ driving\ gear}$

4.3 *Torque = Force x radius*

4.4 *Torque transmitted = gear ratio x input torque*

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

4.6 *Pitch-circle diameter (PCD) =* $\frac{Circular\ Pitch\ (cp)x\ number\ of\ teeth\ (T)}{\pi}$

4.7 *Outside diameter (OD) = PCD + 2 module*

4.8 *Addendum (a) = module (m)*

4.9 *Dedendum (b) = 1,157 m or Dedendum (b) = 1, 25 m*

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

4.11 *Clearance (c) = 0,157 m or Clearance (c) = 0,25 m*

4.12 *Clearance pitch (CP) =* $m\ X\ \pi$

5. PULLEY DRIVES

5.1 $N_1\ D_1 = N_2\ D_2$

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

5.3 *Velocity Ratio =* $\frac{Diameter\ of\ driven\ pulley}{Diameter\ of\ driver\ pulley}$

5.4 *r/min of driving pulley =* $\frac{r/min\ of\ driver\ x\ diameter\ of\ driven\ pulley}{diameter\ of\ driven\ pulley}$

6. KEYS

6.1 *Width of key* $= \frac{Diameter\ of\ shaft}{4}$

6.2 *Thickness of key* $= \frac{diameter\ of\ shaft}{6}$

6.3 *Length of key = 1,5 x diameter of shaft*

6.4 *Standard taper of key : 1 in 100 or 1 : 100*

7. CINCINNATI DIVIVIDING HEAD TABLE FOR MILLING MACHINE

7.1

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*

7.2

Standard change gears										
24 x 2	*28*	*32*	*40*	*44*	*48*	*56*	*64*	*72*	*86*	*100*

Indexing formula $= \frac{40}{N}$ *(Where N = number of divisions)*