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GRADE 12

MECHANICAL TECHNOLOGY

FEBRUARY/MARCH 2014

MARKS: 200

TIME: 3 hours

This question paper consists of 16 pages and a 5-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Start EACH question on a NEW page.
6. Show ALL calculations and units. Round off final answers to TWO decimal places.
7. You may use a non-programmable scientific calculator and drawing/mathematical instruments.
8. The value of gravitational force should be taken as 10 m/s^2 .
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	CONTENT	MARKS	TIME
1	Multiple-choice questions	20	18 minutes
2	Tools and equipment	20	18 minutes
3	Materials	20	18 minutes
4	Safety, terminology and joining methods	50	45 minutes
5	Maintenance and turbines	40	36 minutes
6	Forces and systems and control	50	45 minutes
TOTAL		200	180 minutes

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are given 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 actions is considered dangerous when operating a lathe?
- A Wearing eye protection
 - B Wearing correct clothing
 - C Measuring while the work piece is rotating
 - D Operating the lathe with all guards in place (1)
- 1.2 Which ONE of the following safety regulations applies to the MAGS/MIGS welding process?
- A Check the colour coding on cylinders.
 - B Hold the work piece in your hand during the welding process.
 - C Turn the relief valve very slowly.
 - D Ensure that the welding area is well ventilated. (1)
- 1.3 Which advanced engineering equipment is used to determine the amount of twisting of a bar?
- A Torsion tester
 - B Brinell tester
 - C Tensile tester
 - D Spring tester (1)
- 1.4 Carbon steels are classified according to the percentage of carbon content. High-carbon steel contains less than ... of carbon.
- A 0,10%
 - B 0,30%
 - C 1,50%
 - D 0,60% (1)
- 1.5 ... is added to steel when toughness, hardness and wear resistance are desired.
- A Bronze
 - B Solder
 - C Vanadium
 - D Lead (1)

1.6 Identify the equipment used for a testing procedure in FIGURE 1.1 below.



FIGURE 1.1

- A Gas analyser
- B Spring tester
- C Brinell hardness tester
- D Torsion tester

(1)

1.7 Identify the milling process in FIGURE 1.2 below.

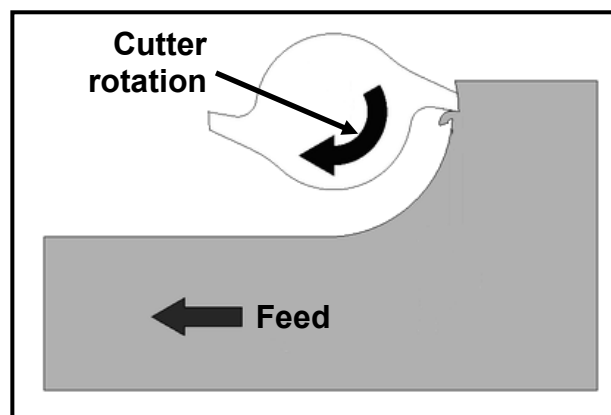


FIGURE 1.2

- A Down-cut milling
- B Up-cut milling
- C Straddle milling
- D Slab milling

(1)

1.8 What is the advantage of down-cut milling?

- A Greater cutting depth is obtained.
- B The feed of the table must be slower.
- C The method is subjected to vibration.
- D Looseness (slack) in the table feed screw must be eliminated. (1)

1.9 Identify the milling cutter in FIGURE 1.3 below.

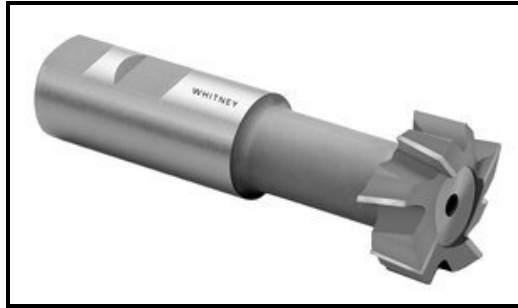


FIGURE 1.3

- A Dovetail cutter
- B Side-and-face cutter
- C T-slot cutter
- D Equal-angle cutter (1)

1.10 What do you understand by the *nick-break test*?

- A Breaking a weld open to examine external defects
- B Checking shear fractures of a weld
- C Checking high-frequency sound effects
- D Breaking open a welded joint to examine internal defects (1)

1.11 Porosity of a welded joint refers to ...

- A metal found in weld metal due to surface contamination.
- B small pinholes in weld metal due to atmospheric contamination.
- C occurs as a cavity at the end of a welded joint.
- D occurs as a cavity at the beginning of a welded joint. (1)

1.12 What will the induced stress be if a load of 50 N is applied to a square bar with a cross-sectional area of $144 \times 10^{-6} \text{ m}^2$?

- A 347 kPa
- B 3,47 kPa
- C 0,347 kPa
- D 34,7 kPa (1)

- 1.13 What does point **X** represent in the stress/strain diagram in FIGURE 1.4 below?

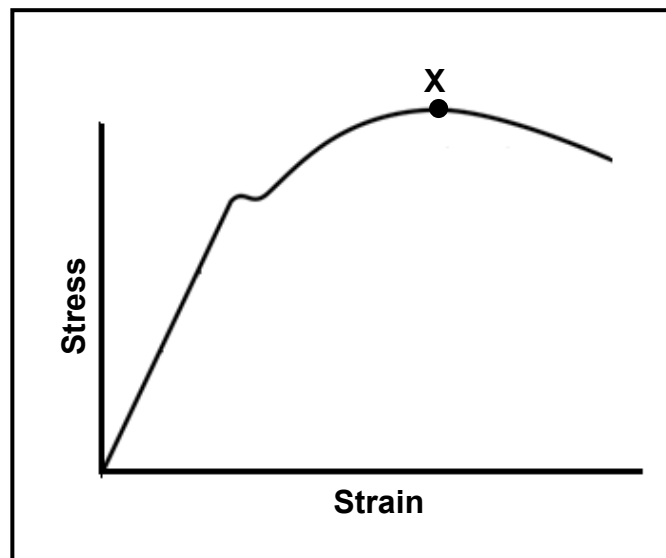


FIGURE 1.4

- A Limit of proportionality
B Elastic limit
C Maximum stress
D Yield point (1)
- 1.14 What does the abbreviation EP stand for in terms of lubricating oil?
- A External pressure
B Extreme pressure
C Excess pressure
D Extra pressure (1)
- 1.15 What is the purpose of a cutting fluid?
- A Act as a non-lubricant
B Make chips stick to the cutter
C Reduce the quality of the finish
D Cools a cutting tool (1)

- 1.16 What is the velocity ratio of the pulley system in FIGURE 1.5 below if the smaller pulley is the driver pulley?

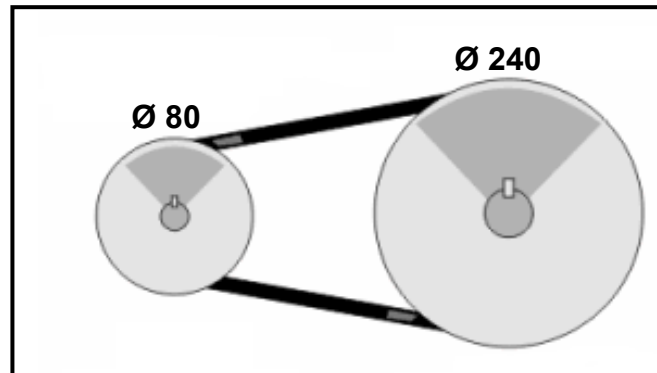


FIGURE 1.5

- A 3 : 1
- B 24 : 1
- C 8 : 1
- D 32 : 1

(1)

- 1.17 Identify the mechanism in FIGURE 1.6 below.

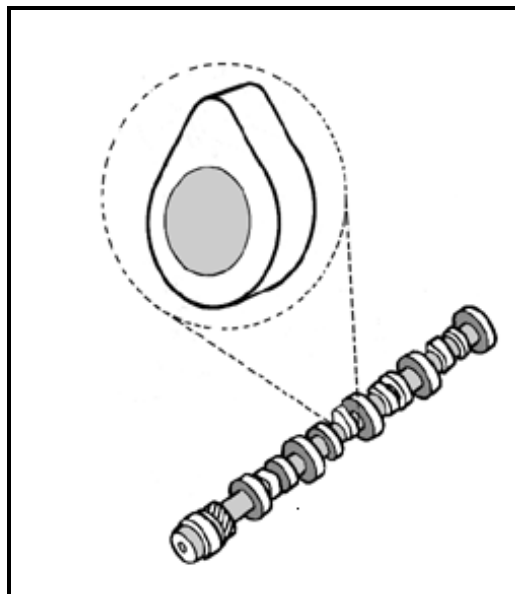


FIGURE 1.6

- A Cam follower
- B Cam guide
- C Cam and shaft
- D Cam rod

(1)

- 1.18 FIGURE 1.7 below shows a rack and pinion as used in the movement of the saddle of a lathe. Choose the correct statement from those given below if the pinion is the driver gear.

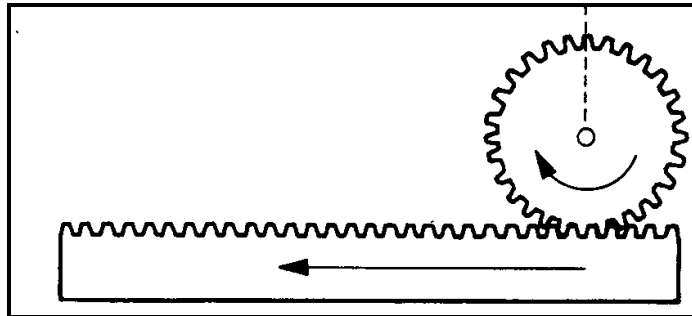


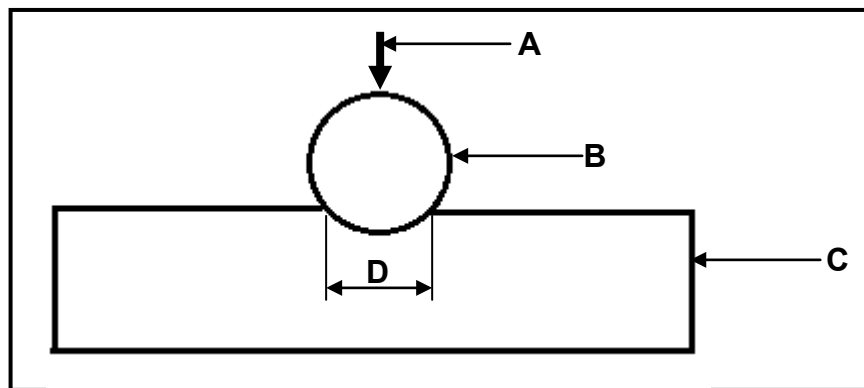
FIGURE 1.7

- A Converts linear motion to rotary motion
B Converts rotary motion to linear motion
C Converts reciprocating motion to linear motion
D Converts linear motion to reciprocating motion (1)
- 1.19 A turbocharger is driven by ...
A gears.
B inlet gases.
C a camshaft.
D exhaust gases. (1)
- 1.20 Scavenging is defined as the removal of ...
A burned gases and filling of the combustion chamber with fresh air.
B fresh air and filling of the combustion chamber with burned gases.
C fuel and filling with fresh air.
D an air and fuel mixture from the combustion chamber. (1)

[20]

QUESTION 2: TOOLS AND EQUIPMENT

- 2.1 Mr Jack needs to carry out a dry compression test on his vehicle's engine. Explain the procedure he needs to follow to carry out the test. (8)
- 2.2 Define the following with reference to the testing of materials:
- 2.2.1 Bending test (2)
- 2.2.2 Tensile test (2)
- 2.3 Name FOUR measurements that can be taken with a multimeter. (4)
- 2.4 FIGURE 2.1 below shows a test using the Brinell hardness tester. Label the sketch (A–D).

**FIGURE 2.1**

(4)
[20]

QUESTION 3: MATERIALS

- 3.1 FIGURE 3.1 below shows a hammer used in the general engineering environment. Answer the questions that follow.

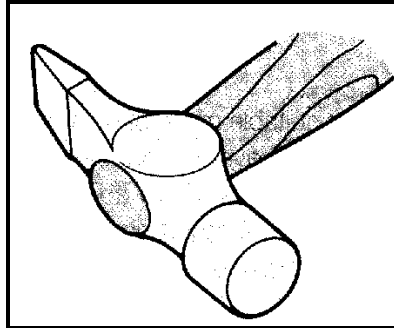


FIGURE 3.1

- 3.1.1 What type of material is used in the manufacturing of the hammer head? (1)
- 3.1.2 Give TWO reasons for using the material in QUESTION 3.1.1. (2)
- 3.1.3 Why is it advisable to subject the hammer head to heat treatment? (2)
- 3.2 FIGURE 3.2 below shows the frame of a greenhouse made from stainless steel tubing. Answer the questions that follow.

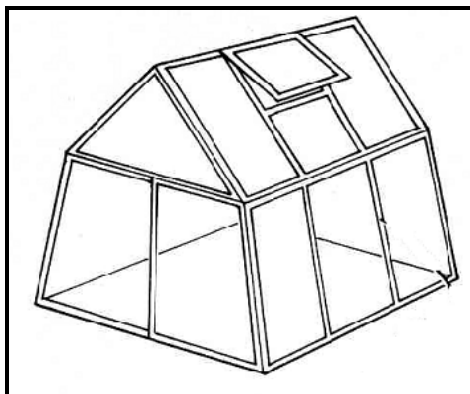


FIGURE 3.2

- 3.2.1 Which THREE properties make stainless steel suitable for this product (frame)? (3)
- 3.2.2 Why was tubing used rather than solid bar? (2)
- 3.2.3 What will be the disadvantage if mild steel is used to manufacture the frame? (2)

- 3.3 FIGURE 3.3 below shows an electrical three-pin plug. Answer the questions that follow.

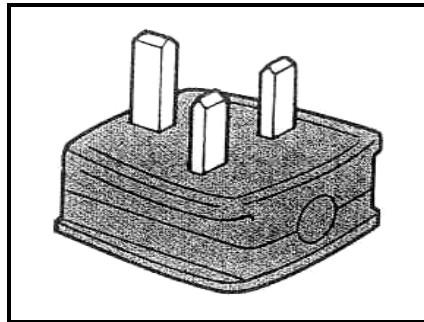


FIGURE 3.3

- 3.3.1 Which type of material is used to manufacture the pins? Give TWO reasons for your answer. (3)
- 3.3.2 Which type of material is used to manufacture the casing? Give TWO reasons for your answer. (3)

- 3.4 FIGURE 3.4 below shows a car bumper made from carbon fibre. State TWO properties of carbon fibre which make it suitable for use in the manufacturing of bumpers.

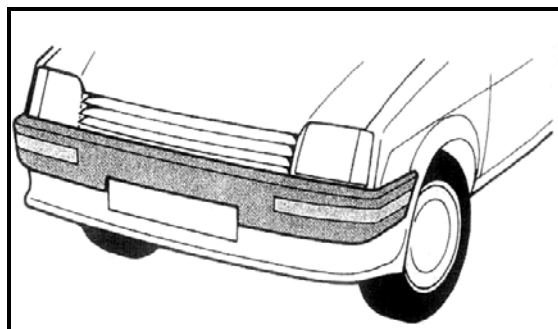
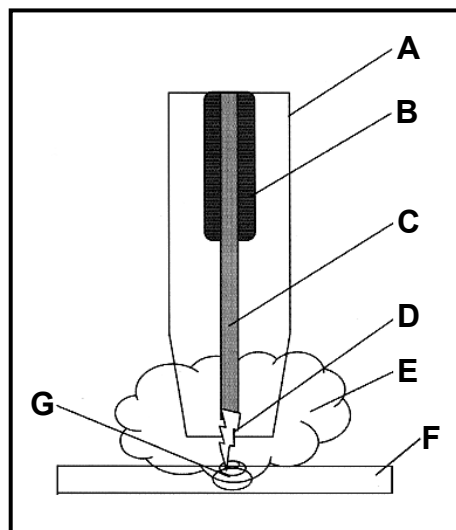


FIGURE 3.4

(2)
[20]

QUESTION 4: SAFETY, TERMINOLOGY AND JOINING METHODS

- 4.1 Solly uses a milling machine to manufacture a hexagonal bolt head. State FOUR safety rules for the safe use of a milling machine. (4)
- 4.2 Rudy uses spring compressors to install coil springs in a vehicle's suspension. State TWO safety rules that he must consider for the safe handling of the spring compressors. (2)
- 4.3 List THREE important safety precautions that should be observed during the MIGS/MAGS welding process. (3)
- 4.4 Calculate the simple indexing for a gear with 17 teeth. (5)
- 4.5 A gear with 91 teeth has to be machined on a milling machine.
(HINT: Use $N = 90$ divisions or $A = 90$ divisions and $n = 91$ for the calculations.)
- 4.5.1 Calculate the indexing required. (5)
- 4.5.2 Calculate the change gears required. (6)
- 4.6 FIGURE 4.1 below shows a schematic drawing of the MIGS/MAGS welding process. Label parts A–G.

**FIGURE 4.1**

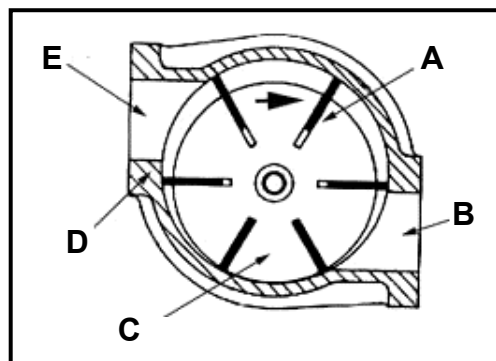
- 4.7 State ONE use of the following milling cutting tools: (7)
- 4.7.1 T-slot milling cutter (1)
- 4.7.2 End mill cutter (1)
- 4.7.3 Slitting saw (1)
- 4.7.4 Form (profile) cutter (1)

4.8 Enid works for Shai Boilers as a learner boilermaker. Help Enid by answering the following questions:

- 4.8.1 Name TWO causes of porosity in a welded joint and ONE way to prevent it. (3)
 - 4.8.2 Explain TWO steps to follow to prevent slag inclusion in a welded joint. (2)
 - 4.8.3 Define the term *distortion* as used in welding. (2)
 - 4.8.4 State THREE factors that need to be considered during the arc welding process to ensure a good weld. (3)
 - 4.8.5 List FOUR advantages of MIGS/MAGS welding. (4)
- [50]**

QUESTION 5: MAINTENANCE AND TURBINES

- 5.1 A great amount of money is spent on maintenance due to bearing failure. Give FOUR reasons for bearing failure. (4)
- 5.2 Why is it important to fit an oil seal to the crankshaft of an internal combustion engine? (2)
- 5.3 Explain the terms *corrosion resistance* and *rust resistance* in motor oil. (2)
- 5.4 Give FOUR reasons for using a cutting fluid when a centre lathe is used. (4)
- 5.5 Most motor vehicle manufacturers recommend that gearbox oil be changed every 50 000 km. Describe the procedure for draining the old oil and filling the gearbox with new oil. (8)
- 5.6 Some people like to increase the performance of their vehicles by using the blower in FIGURE 5.1 below. Answer the questions that follow.

**FIGURE 5.1**

- 5.6.1 Identify the type of blower in FIGURE 5.1. (1)
- 5.6.2 Label parts A–E of the blower. (5)
- 5.6.3 Explain the operation of the blower in FIGURE 5.1. (5)
- 5.7 How are turbochargers and superchargers driven? (2)
- 5.8 Outline THREE advantages of a supercharger. (3)
- 5.9 State THREE advantages of a steam turbine. (3)
- 5.10 State ONE disadvantage of a steam turbine. (1)
- [40]**

QUESTION 6: FORCES AND SYSTEMS AND CONTROL

- 6.1 A 3,5 m long steel wire with a cross-sectional area of $10,08 \times 10^{-3} \text{ m}^2$ hangs vertically with a 3 kN load attached to it. The load causes an increase of 0,5 mm in the length of the wire.

6.1.1 Name the type of stress in the wire material. (1)

Determine by means of calculations:

6.1.2 The stress in the wire material (Answer in MEGA magnitude.) (4)

6.1.3 The strain caused by the load (3)

6.1.4 The elasticity modulus for this material (3)

- 6.2 The gear system in FIGURE 6.1 below is used to control a hoisting device. The driver gear has 56 teeth and rotates at 700 r/min. The idler gear used to change the direction, rotates at 980 r/min. The driven gear has 64 teeth.

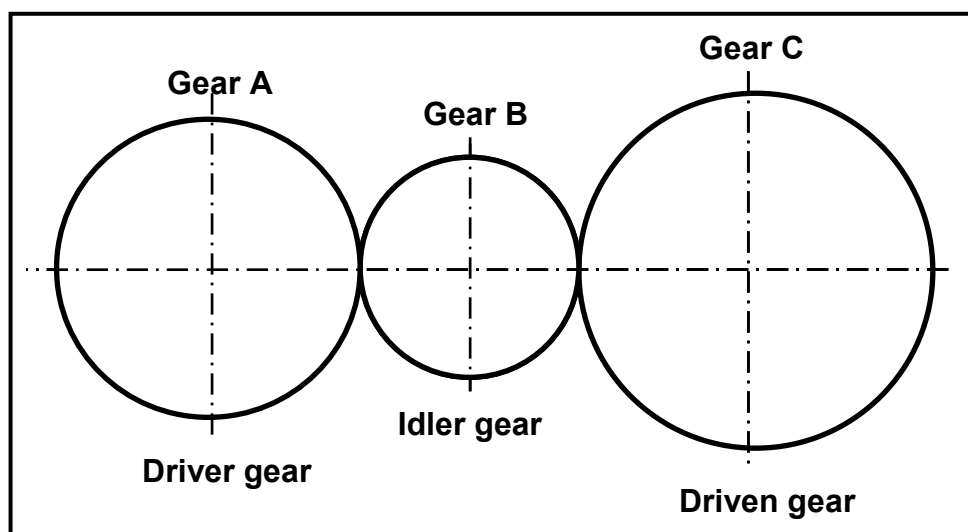


FIGURE 6.1

6.2.1 Determine by means of calculations:

(a) The number of teeth on the idler gear (4)

(b) The rotation frequency of the driven gear (4)

6.2.2 In which direction will the driven gear rotate if the driver gear rotates anti-clockwise? (2)

- 6.3 A drilling machine must be driven at 15 r/s from a pulley with a diameter of 640 mm and a rotation frequency of 9,4 r/s. The tensile force in the tight side of the belt is 320 N. The ratio of the tensile force in the tight side to the tensile force in the slack side is 2,5 : 1. (The thickness of the belt must be ignored.)

Determine by means of calculations:

- 6.3.1 The diameter of the pulley needed on the drilling machine (4)

- 6.3.2 The power that can be transmitted (6)

- 6.4 A diagrammatic representation of a hydraulic press is shown in FIGURE 6.2 below. An applied force of 0,9 kN is needed to complete one stroke of 126 mm. The diameter of piston A is 40 mm and the diameter of piston B is 240 mm.

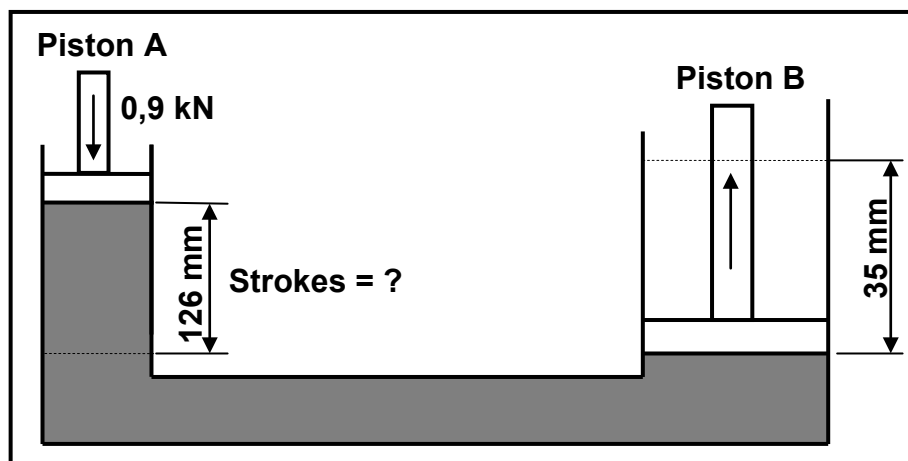


FIGURE 6.2

Determine by means of calculations:

- 6.4.1 The pressure in the system (5)

- 6.4.2 The number of strokes by piston A needed to lift piston B 35 mm. The system has been equipped with the necessary one-way valves to supply adequate hydraulic fluid and pressure during the process. (9)

- 6.5 A single-plate friction clutch is used to transmit 240 Nm torque in an engine/generator combination. The clutch plate has friction material on both sides. The friction coefficient is 0,6. The total applied force onto the pressure plate is 3,4 kN. Calculate the effective diameter of the clutch plate.

(5)
[50]

TOTAL: 200

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

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

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

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

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

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

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

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

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

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

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

$$T_2 = \text{force on slack side}$$

$$T_1 - T_2 = \text{effective force (T}_e\text{)}$$

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

2. FRICTION CLUTCHES

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

where μ = coefficient of friction

W = total force

n = number of friction surfaces

R = effective radius

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

3. STRESS AND STRAIN

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

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

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

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

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

4. HYDRAULICS

$$4.1 \quad \text{Pressure (} P \text{)} = \frac{\text{force (} F \text{)}}{\text{area (} A \text{)}}$$

$$4.2 \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

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

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

5. WHEEL AND AXLE

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

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

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

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. SCREW THREADS

$$7.1 \quad \text{Pitch diameter} = \text{outside diameter} - \frac{1}{2} \text{ pitch}$$

$$7.2 \quad \text{Pitch circumference} = \pi \times \text{pitch diameter}$$

$$7.3 \quad \text{Lead} = \text{pitch} \times \text{number of starts}$$

$$7.4 \quad \text{Helix angle: } \tan \theta = \frac{\text{lead}}{\text{pitch circumference}}$$

$$7.5 \quad \text{Leading tool angle} = 90^\circ - (\text{helix angle} + \text{clearance angle})$$

$$7.6 \quad \text{Following/Trailing angle} = 90^\circ + (\text{helix angle} - \text{clearance angle})$$

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

8. GEAR DRIVES

$$8.1 \quad \text{Power (} P \text{)} = \frac{2 \pi N T}{60}$$

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

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

$$8.4 \quad \text{Torque} = \text{force} \times \text{radius}$$

$$8.5 \quad \text{Torque transmitted} = \text{gear ratio} \times \text{input torque}$$

$$8.6 \quad \text{Module (} m \text{)} = \frac{\text{pitch-circle diameter (PCD)}}{\text{number of teeth (} T \text{)}}$$

$$8.7 \quad N_1 T_1 = N_2 T_2$$

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

$$8.9 \quad \text{Outside diameter (OD)} = \text{PCD} + 2 \text{ module}$$

$$8.10 \quad \text{Addendum (} a \text{)} = \text{module (} m \text{)}$$

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

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

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

$$8.14 \quad \text{Circular pitch (CP)} = m \times \pi$$

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

9.2 Change gears:

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

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