Province of the
EASTERN CAPE
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2021

MECHANICAL TECHNOLOGY: (FITTING AND MACHINING) MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 14 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

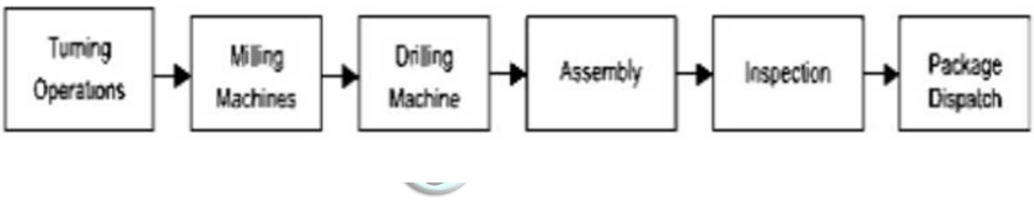
1.1 C ✓
1.2 D ✓
1.3 D ✓
1.4 A ✓
1.5 B ✓
1.6 B ✓ (6 x 1) **[6]**

QUESTION 2: SAFETY (GENERIC)

2.1 **Safety Precautions**

- Pressure gauges must be checked and tested regularly and adjusted or replaced if any malfunctioning occurs. ✓
- Supporting pins that keep the platform at a desired height on the frame must be inspected for damage. ✓
- Check the floor for oil and apparatus for leaks. ✓
- The platform on which the workpiece rests must be rigid and square with the press cylinder. ✓ (Any 2 x 1) (2)

2.2 **Product layout**



✓✓ (2)

2.3 **Perspex shield**
is installed to shield flying objects from harming the operator's eye. ✓ (1)

2.4 2.4.1 **Machine Identification**
Surface grinder ✓ (1)

2.4.2 **Surface grinder parts label**
A Workpiece ✓
B Machine spindle ✓
C Magnetic table ✓
D Grinding wheel ✓ (4)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Heat treatment refers to heating and cooling of metals under controlled conditions in their solid state so as to change their properties. ✓✓ (2)

3.2 **Heat treatment properties**

PROCESS		PROPERTY
3.2.1	Hardening	Very hard, high tensile strength and brittle ✓
3.2.2	Tempering	Tough, hard ✓
3.2.3	Annealing	Soft, ductile, low tensile strength ✓
3.2.4	Normalising	Tough and machinable ✓

(4)

3.3 **Purpose of case-hardening**

- It hardens the surface. ✓
- It provides a wear resistant surface. ✓
- Strengthens core to withstand applied loads. ✓ (Any 2 x 1) (2)

3.4 **Carbon effect**

Steel with low carbon content ✓ will not respond very much to the hardening process. ✓ (2)

3.5 **Workshop tests on materials**

Sound test ✓
Bend test ✓
Filing test
Machining test (Any 2 x 1) (2)

3.6 **Reasons for annealing**

- To relieve internal stresses that may have been set up during other processes. ✓
- To soften them in order to facilitate the machining processes. ✓
- To make material ductile.
- Refine their grain structures.
- Reduce brittleness (Any 2 x 1) (2)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

4.1 A ✓
4.2 D ✓
4.3 A ✓
4.4 A ✓
4.5 A ✓
4.6 B ✓
4.7 A ✓
4.8 C ✓
4.9 D ✓
4.10 B ✓
4.11 B ✓
4.12 A ✓
4.13 A ✓
4.14 B ✓ (14 x 1) **[14]**

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 **Lathe Taper turning**

5.1.1 Set-over $= \frac{D-d}{2}\ x\ \frac{Length\ of\ workpiece}{length\ of\ taper}$

= (75-50)/2 x 400 / 250 ✓
= 12.5 x 1.6
= 20 mm ✓ (2)

5.1.2 $\tan\frac{\theta}{2} = \frac{X}{L}$. ✓
= 12.5 / 250
= 0.05
$= \tan^{-1} 0.05\ x\ 2$ ✓
Θ = 5.724° ✓ (3)

5.2 Milling Cutters.

5.2.1 A – Helical milling cutter ✓
B – Side and face Cutter/ also Accept Staggered tooth cutter ✓
C – Dovetail ✓
D – T–Slot ✓
E – End mill ✓ (5)

5.3 Cutting Square Threads

5.3.1 Lead = Pitch x Number of Starts
= 2 x 12 = 24 mm ✓ (1)

5.3.2 Mean Diameter = OD – 0,5 Pitch
= 85 – 0,5 x 12 ✓
= 91 mm ✓ (2)

5.3.3 Tan θ = Lead / π x Dm
Tan θ = 24 / 91 ✓
Θ = 14,77 ° ✓ (2)

5.4 **Dividing Head components**

A – Index plate: the aim of the index plate is to enable one revolution of the crank to be further subdivided into fractions of a revolution, especially where the fraction is not a factor of 40. ✓

D – Worm-shaft with a Single – start worm engages with a worm gear with 40 teeth. ✓

E – Worm wheel/gear obtain a rotary movement of the spindle. ✓ (3)

[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **GEAR CALCULATIONS:**

6.1.1 Gang Milling: Simultaneously using several cutters of different diameters and forms on the arbor, workpiece can be machined to size in one movement of the milling machine table. ✓ (1)

6.1.2 Straddle Milling: consists of two side and face cutters, separated by spacing collars of required dimensions to produce parallel work in one cut. ✓ (1)

6.2 **Procedure to cut external metric V-screw thread using compound slide method**

- Set up the workpiece in the centre lathe and turn the part to be threaded to the required diameter of the thread. ✓
- Set the compound slide to 30º to the left of the centre line of that cross-slide and set the cutting tool up accurately in the tool post. ✓
- Consult the index plate of the quick-change gear box and shift the levers accordingly for the necessary pitch of the screw thread. ✓
- Start the centre lathe and set the cutting tool at touching point on the workpiece. ✓
- Move the cutting tool a short distance off, to clear the end of the workpiece and feed the compound slide 0.05 mm inwards. ✓
- With the centre lathe revolving, engage the half nuts at the correct line on the threading dial, putting the first cut of the screw thread in progress. ✓
- Stop the centre lathe and check the screw thread pitch with a screw thread pitch gauge. ✓ (Any 5 x 1) (5)

6.3 Definition of Indexing is the process of evenly dividing the circumference of a circular work piece into equally spaced divisions, such as in cutting gear teeth, cutting splines, milling grooves in the reamers and taps. ✓ (1)

6.4 Milling methods

- Up-cut milling ✓
- Down-cut milling ✓ (2)

6.5 Differential indexing

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*

6.5.1 Indexing Required

Indexing = $\frac{40}{A}$ ✓

= 40/120

= $\frac{1}{3}$ x $\frac{22}{22}$ ✓

= 22/66

Indexing is 22 holes in a 66-hole circle ✓ (3)

6.5.2 Change of gears

Gear ratio: $\frac{Driver}{Driven} = \frac{A-N}{A} x \frac{40}{1}$ ✓

$= \frac{120-113}{120} x\ 40$ ✓

$= +\frac{7}{3} x \frac{8}{8}$ ✓

= 56/24 ✓

The driver gear has 56 teeth

The driven gear has 24 teeth ✓ (5)

6.5.3 The direction of motion is clockwise

The crank handle will turn the same direction as index plate ✓ (2)

6.6 **Dove tail Calculations**

Θ = 40°

α = 20° ✓

x = r /(tan α)

= 10 /(tan 20)

= 27,47 mm ✓

X = 80 + 2 R + 2 x ✓✓

= 80 + 20 + (2 x 27,47) ✓

= 154,949 mm ✓ (6)

6.7 **Types of Milling machines**

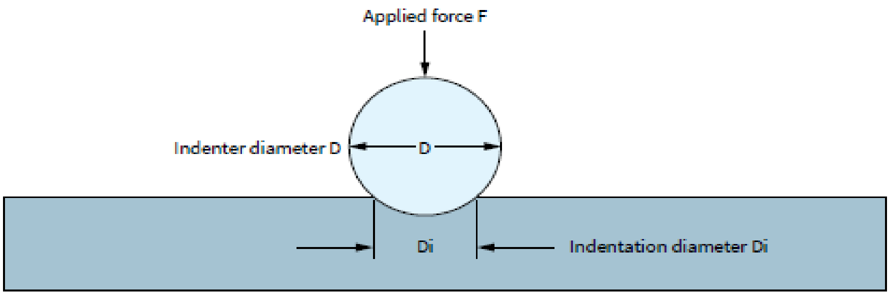
- Vertical milling machine ✓
- Horizontal milling machine ✓ (2)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

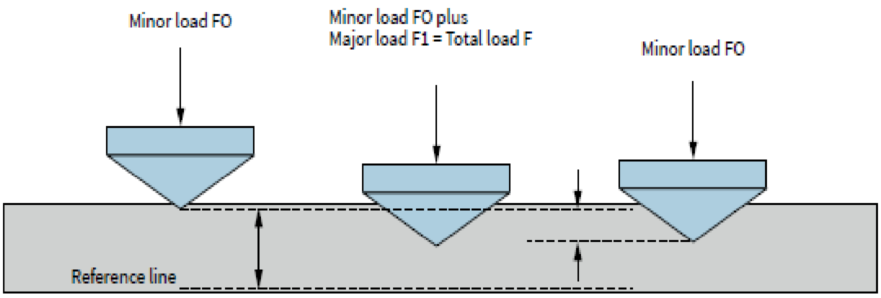
7.1 Hardness Testers

7.1.1 Brinell Hardness tester
The Brinell Hardness Test involves indenting the test material with a piece hardened steel or carbide ball of 10 mm. The diameter of the indentation left in the test material is measured with a low-powered microscope.



✓✓✓ (3)

7.1.2 Rockwell Hardness tester
Rockwell Hardness Test method involves indenting the test material with a diamond cone or hardened steel-ball indenter.



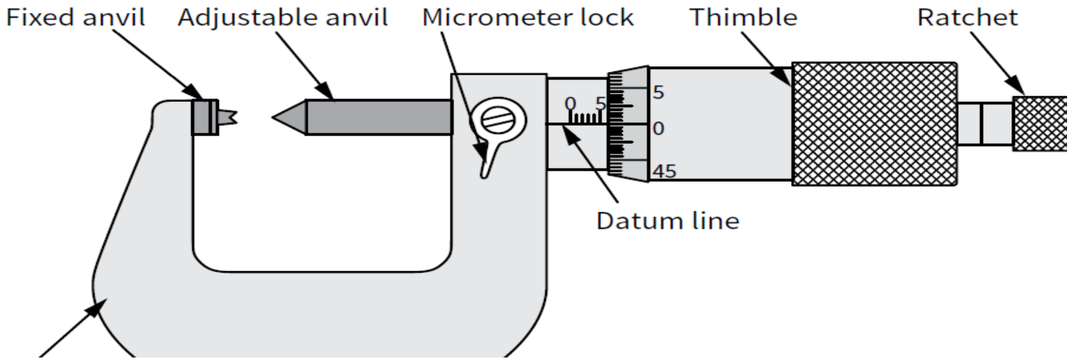
✓✓✓ (3)

7.2 **Hardness measure of a metal.**

- Resistance to penetration ✓
- Elastic hardness ✓
- Resistance to abrasion ✓ (Any 2 x 1) (2)

7.3 Screw thread micrometre

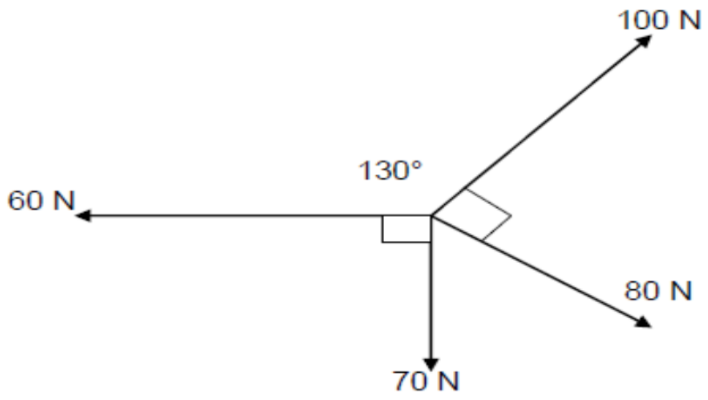
A – ✓ B – ✓ C – ✓ D – ✓ E – ✓



(5)
[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 **Resultant Force Calculations:**



X_{com} = 100 cos 50 + 80 cos 40 - 60 ✓
= **65,56 N** ✓ (2)

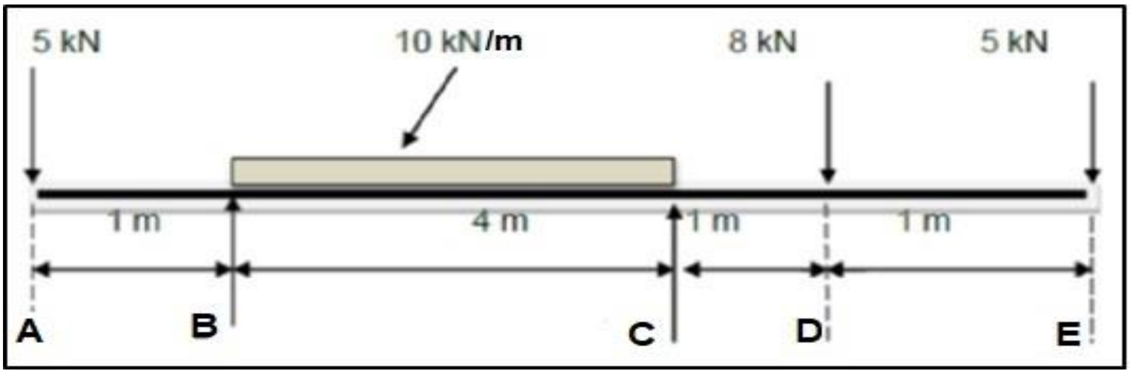
Ycom = 100sin 50 – 80 sin 40 - 70 ✓
= **95,18 N** ✓ (2)

R = $\sqrt{(X^2 + Y^2)}$
R = 115.576 N ✓

Tan θ = y/x ✓
Tan Θ = 95.18/65.56 ✓
Θ = 55.44
= 55.44 ° ✓

Equilibrant = Resultant BUT IN THE OPPOSITE DIRECTION
Equilibrant = 115.567 N at 235.44 ° ✓ (5)

8.2 **Moments**
Converting the UDL to Point Load
4 x 10 = 40 kN @ 3 m from the left hand end ✓



Calculation the Reactions by taking moments:
CLOCKWISE MOMENTS = ANTICLOCK-WISE MOMENTS
(R_C x 4) + (5 x 1) = (5 x 6) + (40 x 2) + (8 x 5) ✓
R_C **= 36,25 kN** ✓
(R_B x 4) + (5 x 2) + (8 x 1) = (40 x 2) + (5 x 5) ✓
R_B **= 21,75 kN** ✓ (5)

8.3 **Stress Calculations**

8.3.1 Tensile Stress Calculations
F = 40 kN; D = 98, d = 67mm: L = 80 mm: E = 90 PGa

$$A = \frac{\pi(D^2 - d^2)}{4} \checkmark$$

$$A = \frac{\pi(0{,}098^2 - 0{,}067^2)}{4}$$

$$= 4{,}02 \times 10^{-3}\ m^2 \checkmark$$

$$\sigma = \frac{F}{A} \checkmark$$

$$\sigma = \frac{40000}{4{,}02 \times 10^{-3}} \checkmark$$

$$\sigma = 9950248{,}76\text{Pa}$$

$$\sigma = 9{,}95\ \text{MPa} \checkmark$$

(5)

8.3.2 The Strain calculations

$$\varepsilon = \frac{\sigma}{E} \checkmark$$

$$\varepsilon = \frac{9{,}95 \times 10^6}{90 \times 10^9} \checkmark$$

$$= 0{,}11 \times 10^{-3}$$

$$\text{or } 1{,}11 \times 10^{-4} \checkmark$$

(3)

8.3.3 Change in length

$$\varepsilon = \frac{\Delta l}{ol} \checkmark$$

$$\Delta l = \varepsilon \times ol \checkmark$$

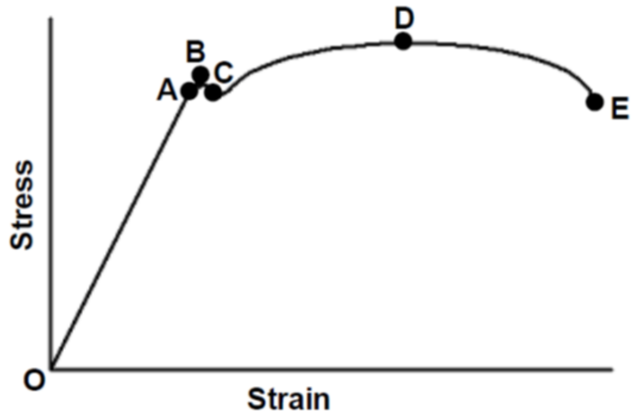
$$= (0{,}11 \times 10^{-3}) \times 0{,}08$$

$$= 8{,}8 \times 10^{-6}\text{m} \checkmark$$

$$= 8{,}8 \times 10^{-3}\ \text{mm}$$

(3)

8.4 **Stress/Strain diagram**



✓ (Diagram shape)

A – Limit of Proportionality ✓
B – Elastic limit ✓
C – Yield point ✓
D – Maximum Force/Point ✓
E – Point of Fracture ✓ (6)

8.5 FOS stands for Factor Of Safety or Safety Factor. ✓✓ (2)
[33]

QUESTION 9: MAINTENANCE

9.1 **Material Classifications**

9.1.1 PVC – Thermoplastic ✓ (1)

9.1.2 Glass fibre – Thermo-setting plastic ✓ (1)

9.1.3 Nylon – Thermoplastic ✓ (1)

9.2 Reasons for using cutting fluid when working on the centre lathe.
- It prolongs the life of a cutting tool. ✓
- It prevents the shavings or metal chips from sticking and fusing to the cutting tool. ✓
- It will carry away the heat generated by the turning process.
- It flushes away shavings/metal chips.
- It improves the quality of the finish of the turned surface. (Any 2 x 1) (2)

9.3 Gear Drives Maintenance.
- Checking and replenishment of lubrication levels ✓
- Ensuring that gears are properly secured to shafts ✓
- Cleaning and replacement of oil filters
- Reporting excessive noise and wear, vibrations and overheating for expect attention. (Any 2 x 1) (2)

9.4 Reasons for the use of carbon fibre

- It is light in weight. ✓
- It is tougher and stronger. ✓
- It can be bent to any shape when heated above 150 ºC. (Any 2 x 1) (2)

9.5 **ONE property and ONE use of each composite**

Composite		Property	Uses
9.5.1	Teflon	• Resistant to water, grease, heat and corrosion ✓ • Needs no lubrication • Very low co-efficient of friction (Any 1)	Orthopaedic and prosthetic appliances, hearing aids, joints, upholstery, electric insulation and non-stick coating pans ✓ (Any 1)
9.5.2	Vesconite	• Withstands high temperatures • self lubrication ✓ • resistant to water, grease heat and corrosion. • good machinability. (Any 1)	• Orthopaedic and prosthetic appliances. ✓ • Hearing aid • Upholstery (Any 1)
9.5.3	Baskelite	• heat resistant ✓ • Brittle in nature (Any1)	• Aircraft Components, bearings, brake linings and laminated material ✓ (Any1)

(6)

9.6
- Contact pressure ✓
- Temperature ✓
- Sliding velocity ✓
- Type of a lubricant ✓
- Surface roughness ✓ (Any 3 x 1) (3)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Square Thread Calculations:**
T = 48 mm ; m = 3

10.1.1 PCD = T x m
= 48 x 3 = **144 mm** ✓✓ (2)

10.1.2 Add = Module = **3 mm** ✓ (1)

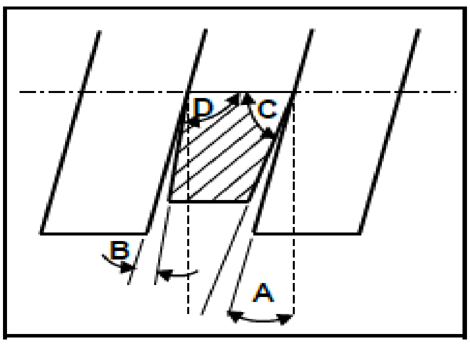
10.1.3 Clearance = 0,157 x 3
= 0,471 mm ✓✓ (2)

10.1.4 Ded = 1,157 x 3
= 3,471 mm ✓✓ (2)

10.1.5 OD = PCD + 2 x 3
= 150 mm ✓✓ (2)

10.1.6 Circular Pitch
= π x m
= π x 3 = **9,424 mm** ✓ (1)

10.2 Left-hand square screw thread



A – Leading Angle ✓ (1)
B – Following or Trailing Angle ✓ (1)
C – Clearance ✓ (1)
D – Helix angle ✓ (1)

10.3 A multi-start thread allows for a faster travel or movement and is more efficient as it loses less power through friction compared to single start thread. ✓✓ (2)

10.4 Screw Thread fit is a combination of allowances and tolerances and a measure of tightness or looseness between the bolt and nut. ✓✓ (2)
[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 Rotational velocity is where a body rotates (spin) around its axis. It is the rotation rate or how fast a body revolves or turns. It is measured in radians per second. ✓✓ (2)

11.2 **Hydraulic system calculations**

11.2.1 **Calculate the Fluid pressure**

$$A_A = \frac{\pi D_A^{\;2}}{4} \quad ✓$$
$$= \frac{\pi 0.04^2}{4}$$
$$= 1{,}26 \times 10^{-3}\ m^2 \quad ✓$$

$$P_A = \frac{F_A}{A_A}$$
$$= \frac{275}{1{,}2566 \times 10^{-3}}\ Pa \quad ✓$$
$$= 218844\ Pa$$
$$= 218{,}84\ kPa \quad ✓$$

(4)

11.2.2 Load on the piston B

$$A_B = \frac{\pi D^2}{4}$$
$$= \frac{\pi 0.075^2}{4}$$
$$= 4{,}42 \times 10^{-3}\ m^2 \quad ✓$$

$$P_B = \frac{F_B}{A_B} \quad ✓$$
$$F_B = P_B \times A_B$$
$$= (218{,}85 \times 10^3) \times (4{,}42 \times 10^{-3}) \quad ✓$$
$$= 967{,}32\ N$$
$$Mass = \frac{967{,}32\ N}{10}$$
$$= 96{,}73\ kg \quad ✓$$

(4)

11.2.3 **Hydraulic System Applications**

- Machine tools, ✓ motor vehicle, ✓ hydraulic jacks ✓ (Any 2 x 1) (2)

11.3 Hydraulics refers to the transmission and control of forces and movement by means of fluid. Fluid (generally oil) is used to transmit energy. ✓✓ (2)

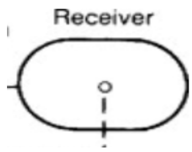
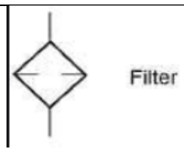
11.4 **Belt Drive Calculations**

$N_{motor} \times D_{motor} = N_{blade} \times D_{blade}$

$130 \times 1205 = 385 \times D_{blade}$ ✓

$D_{blade} = 406{,}883$ pm ✓ (2)

11.5 **Pneumatic symbols**

11.5.1	Pump	 ✓✓	
11.5.2	Air receiver	 ✓✓	
11.5.3	Filter	 ✓✓	(6)

11.6 **Gear-Drive system calculations:**

Data:

11.6.1 Rotation speed of Electric motor

$$\frac{N_{INPUT}}{N_{OUTPUT}} = \frac{T_B \times T_D \times T_F}{T_A \times T_C \times T_E}$$

$$N_{INPUT} = \frac{T_B \times T_D \times T_F}{T_A \times T_C \times T_E} \times N_{OUTPUT}$$ ✓

$$N_{INPUT} = \frac{36 \times 46 \times 60}{18 \times 16 \times 40} \times 160$$ ✓

$$= 1380 \ r/\min$$ ✓

(3)

11.6.2 Velocity ratio

$$VR = \frac{N_{INPUT}}{N_{OUTPUT}}$$

$$= \frac{1380}{160}$$ ✓

$$= 8{,}625 : 1$$

$$= 8{,}63 : 1$$ ✓

(2)

11.6.3 Driven will rotate Clockwise ✓ (1)

[28]

TOTAL: 200