NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2017

MECHANICAL TECHNOLOGY

MARKING GUIDELINES

Time: 3 hours 200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1 MULTIPLE-CHOICE QUESTIONS

1.1 C

1.2 B

1.3 B

1.4 D

1.5 D

1.6 C

1.7 D

1.8 A

1.9 A

1.10 D

1.11 D

1.12 C

1.13 A

1.14 D

1.15 A

1.16 A

1.17 B

1.18 C

1.19 A

1.20 B

QUESTION 2 SAFETY

2.1 **Personal safety – Spot welder**

- Wear protective clothes.
- Wear safety glasses.
- Wear gloves.

2.2 **Safety – Tensile tester**

- Area around tester must be fenced off.
- Only one person in fenced-off area during test.
- Dial indicator must be mounted properly.
- Front of the indicator must touch the bottom of the tester.
- Shield must be over sample that is tested.
- For steel and duralumin the hand wheel must be turned only half a turn at a time.
- For plastic a one-fifth turn is sufficient for first three turns.

2.3 **Safety – Valve spring compressor**

- Nose of spring compressor must fit tightly over valve spring retainer.
- Specifications must be determined before spring compressor is used.
- Do not compress the spring more than what is prescribed in the specifications.

2.4 **Safety – Bearing and gear puller**

- Make sure that the puller is the correct one for the task.
- Do not hit the puller with a hammer.
- Use the correct spanner to tighten the clamp and to pull off the object.
- Make sure that the puller is used at 90° to the work piece.
- Legs must not be worn out.
- Make sure that the clamps do not slip and cause injuries.
- Use a screen to prevent injuries.
- Do not stand directly behind the puller – this may cause injuries.

QUESTION 3 TOOLS AND EQUIPMENT

3.1 Tests

3.1.1 The **function** of the **oil pressure tester** is to test the oil pressure in an engine. **Reason:** To determine whether it is according to specification.

3.1.2 The **function** of the **hardness tester** is to test hardness of metals. **Reason:** It gives an indication of the metal's tensile strength.

3.1.3 The **function** of the **torsion teste**r is to test the relationship between momentum and torque applied to the material. **Reason:** To examine the effect of material length and torsional deflection.

3.2 Screw thread micrometer reading

Reading = 2.00 mm
+ 0.12 mm
2.12 mm

3.3 Possible problems that may be diagnosed:

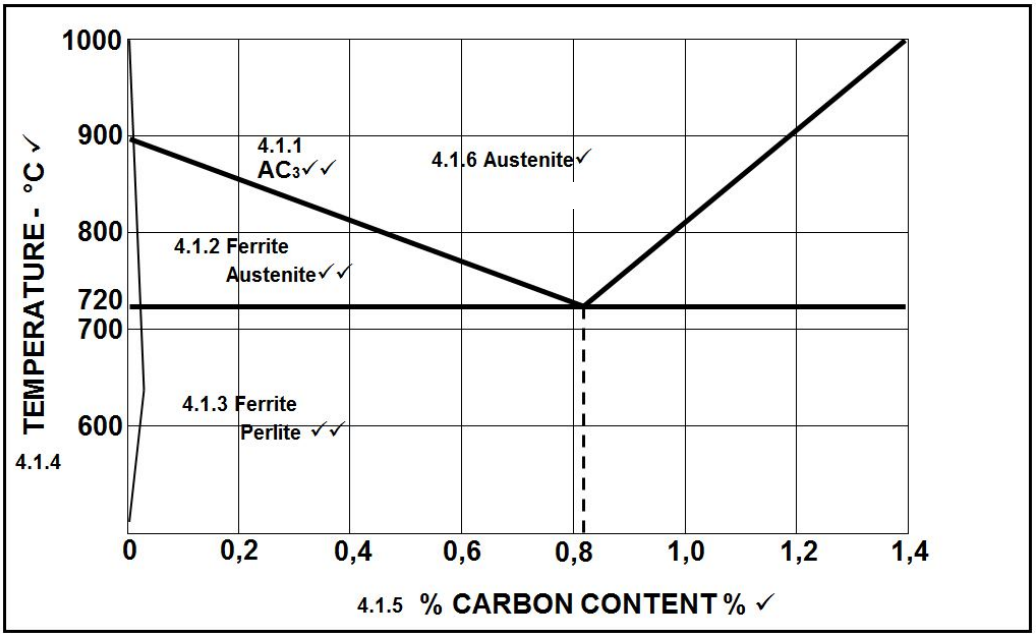
- Leaking piston rings
- Leaking valves
- Leaking cylinder head gasket
- Cracked engine block
- Cracked cylinder head

3.4 Multimeter tests

- Voltage
- Resistance
- Continuity
- Current
- Transistors

QUESTION 4 MATERIALS

4.1 Iron-carbon equilibrium diagram



4.2 Advantage of nitration process on crankshaft surface:

- Very hard surface is obtained.
- It leaves some compression stress on the surface that counters metal fatigue to some degree.

4.3 Machining of cams on camshaft:

Increases cams' maximum resistance to wear.

QUESTION 5 TERMINOLOGY

5.1 Calculation – Gib head key

5.1.1 Width of key $= \frac{\text{Diameter of shaft}}{4}$

$= \frac{70}{4}$

$= 17{,}5 \text{ mm}$

5.1.2 Thickness of key $= \frac{\text{Diameter of shaft}}{6}$

$= \frac{70}{6}$

$= 11{,}67 \text{ mm}$

5.1.3 Length of key = 1,5 × diameter

$= 1{,}5 \times 70$

$= 105 \text{ mm}$

5.2 Milling cutter for spur gear:

- Involute cutter

5.3 Disadvantages of cutting screw thread – carriage method:

- The tip of the cutting tool, which is the weakest part of the cutting tool, does most of the cutting.
- Because both sides of the cutting tool do the cutting, the chips curl into each other. This may cause the screw thread to tear.
- A large load may damage the cutting tool/cutting edges.
- Slow method. (Any 2 × 1)

5.4 Indexing:

$\text{Indexing} = \frac{40}{n}$

$= \frac{40}{76}$

$= \frac{10}{19} \times \frac{3}{3}$

$= \frac{30}{57}$

No full turns and 30 holes in a 57-hole plate

5.5 Advantages of up-cut milling

- A quick feed can be used.
- Vibration is less.
- Less stress on the cutter and arbor.

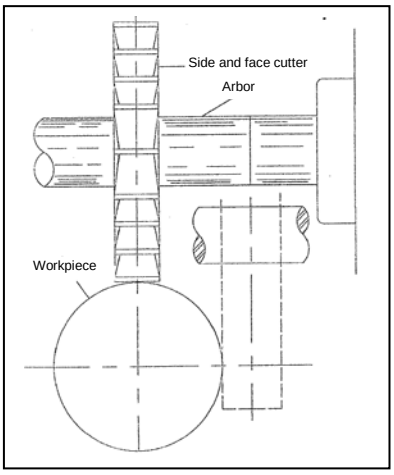
- There is a positive pressure on the feed screw spindle and nuts because the direction of the cutter is against the direction of the feed.
- Metals with hard shale start the cut below the shale where the metal is softer. This extends the life of the cutter.
- More accurate during cutting.
- Better finish.

5.6 **Purpose for using the straddle-milling method**

- To mill the heads of square and hexagon bolts.

5.7 **Milling machine set-up for keyway**

- Fit a milling cutter with staggered teeth on the arbor.
- Fasten the workpiece in the chuck of the dividing head.
- If the workpiece is rectangular, move table to get workpiece in required position.
- Hold the end of steel ruler against the side of the cutter.
- Move saddle to set up cutter at correct distance from the side of the workpiece.
- Use a piece of tissue paper as an indicator between workpiece and cutter to mark point of contact.
- Lift the knee of milling machine until cutter tears away the tissue paper.
- Set the index plate with scale divisions to zero in relation to index line.
- Move the workpiece back from the cutter.



5.8 **Function of screw thread micrometer**

- To measure pitch diameter of a screw thread.

5.9 **Lead of a screw thread is**

- distance that a nut moves forwards on the screw thread.
- all along the screw thread.
- when it is turned through one full revolution.

QUESTION 6 JOINING METHODS

6.1 **Shielding gas**

- It forms the arc plasma, stabilises the arc on the metal being welded and protects the arc and molten pool.
- Prevents atmospheric contamination.
- Prevents excessive spatter.

6.2 **Relationship between voltage and wire feed**

Higher voltage causes a higher melting rate, therefore a higher feed rate is needed.

6.3 **Porosity in an MIG welding joint**

- Atmospheric contamination
- Surface contamination
- Rusted MIG welding wire
- Strong wind (e.g. welding outside)
- Gas flow too high
- Incorrect welding technique

6.4 6.41 **Porosity**

- Use correct current setting.
- Maintain a longer arc.
- Use correct welding rods.
- Check for impurities – surface.
- Shield the welding process.
- Correct welding technique.

6.4.2 **Lack of fusion**

- Use the correct welding technique.
- Use the correct size welding rod.
- Use the correct current setting.
- Prepare the plate bevel (V-gap) correctly.

6.5 **Destructive tests**

6.5.1 **Free-bend test**

- Measures the ductility of the weld deposit or the heat-affected area adjacent to the weld joint. OR
- Determines the percentage elongation of the weld metal.

6.5.2 **Nick break test**

- Determines the internal quality of the weld metal OR can indicate internal defects.

6.6 **Advantage of ultrasonic testing versus similar tests**

- System is fast.
- Results almost immediately available.
- No additional material needed.
- Test piece is not damaged.

6.7 **Requirements for an acceptable welding joint**

- Profile shape – profile must blend smoothly with adjacent surface.
- Surface uniformity – total length of the welding joint's surface must be uniform.
- Overlapping – there may be no overlapping at the toe of the welding joint.
- Undercutting – no undercutting may occur in welding joints.
- Penetration bead – butt welding joints coming from one side only and manufactured without a support beam may have a slight penetration bead.
- Root gap – butt welding joints coming from one side only and without a support beam may have a root opening.
- Free of cracks – the weld metal, heated area and surrounding base metal must display no cracks.
- Surface defects – no surface defects must be visible.

6.8 **Transmitter-receiver unit**

- A unit that is used to transmit a sound wave and then listen as a receiver to the ultrasonic wave as the metal reflects it back. OR
- To show defects.

QUESTION 7 FORCES

7.1 7.1.1 Sum of vertical and horizontal components

Force	Horizontal components	Vertical components
160 N	X = 160 cos 0° = 160 N	Y = 160 sin 0° = 0 N
75 N	X = 75 cos 150° = –64,951 N	Y = 75 sin 150° = 37,5 N
200 N	X = 200 cos 225° = –141,421 N	Y = 200 sin 225° = –141,421 N
90 N	X = 90 cos 240° = –45 N	Y = 90 sin 240° = –77,942 N
	–91,372 N	–181,863 N

7.1.2 Resultant force

$R^2 = X^2 + Y^2$
$R^2 = 91{,}372^2 + 181{,}863^2$
$R^2 = 41\ 422{,}99315$
$R = \sqrt{41\ 422{,}99315}$
$R = 203{,}53$ N

7.1.3 Direction of resultant force

$$\tan Ø = \frac{\text{Sum Y}}{\text{Sum X}}$$

$$\tan Ø = \frac{181{,}863}{91{,}372}$$

$\tan Ø = 1{,}99$

Angle = 63,32°

7.2 Magnitude of force

Stress = Pa
Diameter = m
Force = N

$$\text{Stress} = \frac{\text{force}}{\text{area}}$$

Force = Stress × Area

$$= 5200000 \times \frac{\pi \times 0{,}035^2}{4}$$

$$= 5{,}2 \times 10^6 \times 9{,}621127502 \times 10^{-4}$$

$$= 5002{,}99 \text{ N}$$

$$= 5 \text{ kN}$$

7.3 **Stress and strain**

E = Break stress / Break point

7.4 **Reactions**

Taking moments around A

$A \times 7,5 = (600 \times 4) + (225 \times 6,25) + (400 \times 8,5)$

$$A = \frac{7206,25}{7,5}$$

$A = 960,833$ N

Taking moments around B

$(225 \times 1,25) + (600 \times 3,5) = (B \times 7,5) + (400 \times 1)$

$281,25 + 2\,100 = 7,5B + 400$

$$B = \frac{1981,25}{7,5}$$

$B = 264,166$ N

QUESTION 8 MAINTENANCE

8.1 **Preventative maintenance**

Preventative maintenance is the systematic inspection, detection and correction of systems before they break down.

8.2 **Authoritative body in oil classification**

American Petroleum Institute (API)

8.3 **Pour point**

Pour point is the lowest temperature at which a liquid remains a fluid.

8.4 **Cutting fluid mixture**

- Cutting fluid consists of soluble oil and water.

8.5 **Maintenance of belt drive systems**

- Belts tend to stretch after a period of use, therefore they must be tightened from time to time and checked for correct alignment.

or

- To transmit maximum power/torque without any slippage.

8.6 **Reason for machining flywheel**

- The clutch plate presses against the flywheel. As a result of friction between the clutch and the flywheel grooves are formed in the flywheel. The grooves/cracks will then have to be removed through a precision machining process before the new clutch plate is fitted.

or

- To ensure maximum coefficient of friction on area between clutch plate and flywheel.

or

- To reduce wear on a new clutch plate.

8.7 **Lubrication of hypoid gears**

- It is difficult to lubricate hypoid gears because they shift over each other rather than roll, this action therefore rubs off the lubrication.

QUESTION 9 SYSTEMS AND CONTROL

9.1 Gear drives

9.1.1 Number of teeth of idler gear

$$N_A \times T_A = N_B \times T_B$$

$$T_B = \frac{N_A \times T_A}{N_B}$$

$$= \frac{600 \times 40}{800}$$

$$= 30 \text{ teeth}$$

9.1.2 Rotation frequency of the driven gear

$$N_B \times T_B = N_C \times T_C$$

$$N_C = \frac{N_B \times T_B}{T_C}$$

$$= \frac{800 \times 30}{60}$$

$$= 400 \text{ r/min}$$

OR

$$N_A \times T_A = N_C \times T_C$$

$$N_C = \frac{N_A \times T_A}{T_C}$$

$$= \frac{600 \times 40}{60}$$

$$= 400 \text{ r/min}$$

9.2 Pulley drives

9.2.1 Diameter of the driven pulley

$$N_1 \times D_1 = N_2 \times D_2$$

$$D_2 = \frac{N_1 \times D_1}{N_2}$$

$$= \frac{8,2 \times 700}{14}$$

$$= 410 \text{ mm}$$

9.2.2 Power transmitted:

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

$$P = (400 - 160)\pi \times 0,7 \times 8,2$$

$$= 4327,86 \text{ Watts}$$

$$= 4,32 \text{ kW}$$

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

$$T_2 = \frac{400}{2,5}$$

$$= 160 \text{ N}$$

OR

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

$P = (400 - 160)\pi \times 0,41 \times 14$

$= 4327,82$ Watts

$= 4,32$ kW

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

$T_2 = \frac{400}{2,5}$

$= 160$ N

9.3 Hydraulics

9.3.1 Pressure in the system

Area A

$A = \frac{\Pi D^2}{4}$

$A = 0,7853981 \times (0,06^2)$

$A = 2,8274 \times 10^{-3}$ m²

$P = \frac{F}{A}$

$P = \frac{600}{2,8274 \times 10^{-3}}$

P = 212 206,5908 Pa

9.3.2 Distance X that moves piston B

Area B

$A = \frac{\Pi D^2}{4}$

$A = 0,7853981 \times (0,2^2)$

$A = 0,031415926$ m²

Distance of A × Area of A = Distance × X × Area of B

$X = \frac{0,065 \times 0,0028274}{0,031415926}$

$X = 5,84999 \times 10^{-3}$

X = 5,84 mm

Distance X = 5,84 mm

9.4 **Airbags**

These may be seen as a passive safety device because the driver and passengers do not have to activate the airbags or do anything to be protected by the airbags.

QUESTION 10 TURBINES

10.1 **Reaction turbine**

- Francis
- Kaplan
- Tyson
- Gorlov

10.2 **Runaway speed**

Runaway speed refers to a turbine's rotational speed at full flow without any load.

10.3 **Controlling speed of steam turbine**

To prevent the turbine rotor from resulting in an overspeed trip, and continuing to accelerate and breaking apart.

10.4 **Advantages of gas turbine**

- Smooth operation owing to fewer moving parts.
- No moving parts such as a piston that causes internal friction and wear.
- Easy starting.
- Uses a wide range of fuels.
- No water cooling system is required.
- Non-toxic exhaust gasses do not cause pollution problems.
- Requires little routine maintenance.
- Very high power-to-weight ratio compared to piston engine.
- Moves only in one direction with much less vibration than a piston engine.
- Low operating pressure.
- High operating speed.
- Low lubrication cost and consumption.

10.5 **Sections of turbocharger**

- Turbine section
- Compressor section

10.6 **Volumetric efficiency**

The ability to fill the cylinder with air.

10.7 **Altitude above sea level**

- At high altitude less oxygen is available for combustion.
- Power losses occur.

10.8 **Advantages of centrifugal charger over the twin-screw supercharger**

- Centrifugal chargers are small/compact.
- Centrifugal chargers are lightweight.
- They are mounted on the front of the engine instead of on top.
- Twin-screw superchargers are mounted on top of the engine, which requires space.
- Rotors of a twin-screw supercharger require very accurate and precision manufacturing.

10.9 **Purpose of the recuperator**

A recuperator is a heat exchanger that transfers exhaust heat before combustion to the compressed air.

Total: 200 marks