# THE UNIVERSITY OF ZAMBIA
## SCHOOL OF ENGINEERING

## DEPARTMENT OF MECHANICAL ENGINEERING

## MEC 3102 PRODUCTION TECHNOLOGY AND ELECTRICITY & ELECTRONICS II

## TUTORIAL SHEET NO. 1 THEORY OF METAL MACHINING
**Submit Q15, Q16, Q17, Q18 and Q19 as Assignment 1**

**DUE DATE: 29TH September 2021**

**(NB: Marks will be deducted for not showing your work)**

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Q1. **What distinguishes machining from other manufacturing processes?**

In machining, material is removed from the workpart so that the remaining material is the desired part geometry.

Q2. **Identify some of the reasons why machining is commercially and technologically important**.
The reasons include:
(1) its applicability to most materials;

(2) its capability to produce a variety of geometries to a part;

(3) it can achieve closer tolerances than most other processes; and

(4) it can create good surface finishes.

Q3. **Name the three most common machining processes.**

The three common machining processes are:

(1) turning, (2) drilling, and (3) milling.

Q4. **What are the two basic categories of cutting tools in machining? Give an example of a machining Operation that uses each of the tooling types**.

The two categories are:

(1) single -point tools, used in operations such as turning and boring; and

(2) multiple-edge cutting tools, used in operations such as milling and drilling.

Q5. **Identify the parameters of a machining operation that are included within the scope of cutting conditions.**

Cutting conditions include:

Speed, feed, depth of cut, and whether or not a cutting fluid is used.

Q6. **Define the difference between roughing and finishing operations in machining.**

A roughing operation is used to remove large amounts of material rapidly and to produce a part geometry close to the desired shape. A finishing operation follows roughing and is used to achieve the final geometry and surface finish.

Q7. **What is a machine tool?**

A machine tool can be defined as a power-driven machine that positions and moves a tool relative to the work to accomplish machining or other metal shaping process.

Q8. **What is an orthogonal cutting operation?**

Orthogonal cutting involves the use of a wedge- shaped tool in which the cutting edge is perpendicular to the direction of speed motion into the work material.

Q9. **Name and briefly describe the three types of chips that occur in metal cutting.**

The three types are:

(1) Discontinuous, in which the chip is formed into separated segments;

(2) Continuous, in which the chip does not segment and is formed from a ductile metal;

(3) Continuous with built-up edge (BUE), which is the same as (2) except that friction at the tool-chip Interface causes adhesion of the work material to the tool rake face.

Q10. **Describe in words what the Merchant equation tells us**

The Merchant equation states that the shear plane angle increases when rake angle is increased and friction angle is decreased.

Q11. What is the specific energy in metal machining?

Specific energy is the amount of energy required to remove a unit volume of the work material

Q12.The cutting conditions in a turning operation are $v$ = 2 m/s, $f$ = 0.25 mm, and $d$ = 3.0 mm. The tool rake angle = 10° which produces a deformed chip thickness $t_c$ = 0.54 mm.

Determine:

(a) Shear plane angle,

(b) Shear strain, and

(c) Material removal rate.

Use the orthogonal cutting model as an approximation of the turning process.

Q13. Turning is performed on a work material with shear strength of 250 MPa. The following conditions are used: $v$ = 3.0 m/s, $f$ = 0.20 mm/rev, d = 3.0 mm, and rake angle = 7° in the direction of chip flow. The resulting chip ratio = 0.5. Using the orthogonal model as an approximation of turning, determine: (a) the shear plane angle;

(b) the shear force;

(c) cutting force and feed force.

Q14. Orthogonal cutting is performed on a metal whose mass specific heat = 1.1 J/g-C, density = 2.7 $g/cm^3$ and thermal diffusivity = 0.9 $cm^2/s$ . The following cutting conditions are used: $v$ = 4.0 m/s, $t_0$ = 0.3 mm and $w$ = 2.0 mm. The cutting force is measured at $F_c$ = 1100 N. Using Cook's equation, determine the cutting temperature if the ambient temperature = 20°C.

**Q15**.During a turning operation, a tool-chip thermocouple was used to measure cutting temperature. The following temperature data were collected during the cuts at three different cutting speeds (feed and depth were held constant): (1) $v$ = 100 m/min, $T$ = 505°C, (2) $v$ = 130 m/min, $T$ = 552°C, (3) $v$ = 160 m/min, $T$ = 592°C. Determine an equation for temperature as a function of cutting speed that is in the form of the Trigger equation.

**Q16** In a turning operation, spindle speed is set to provide a cutting speed of 1.8 m/s. The feed and depth of cut are 0.30 mm and 2.6 mm, respectively. The tool rake angle is 8°. After the cut, the deformed chip thickness is measured to be 0.49 mm. Determine (a) shear plane angle, (b) shear strain, and (c) material removal rate. Use the orthogonal cutting model as an approximation of the turning process.

**Q17**. The cutting force and thrust force in an orthogonal cutting operation are 1470 N and 1589 N, respectively. The rake angle = 5°, the width of the cut = 5.0 mm, the chip thickness before the cut = 0.6, and the chip thickness ratio = 0.38. Determine (a) the shear strength of the work material and (b) the coefficient of friction in the operation.

**Q18**. Low carbon steel having a tensile strength of 300 MPa and a shear strength of 220 MPa is cut in a turning operation with a cutting speed of 3.0 m/s. The feed is 0.20 mm/rev and the depth of cut is 3.0 mm. The rake angle of the tool is 5° in the direction of chip flow. The resulting chip ratio is 0.45. Using the orthogonal model as an approximation of turning, determine (a) the shear plane angle, (b) shear force, (c) cutting force and feed force.

**Q19**. Orthogonal cutting is performed on a metal whose mass specific heat = 1.0 J/g-C, density = 2.9 g/cm$^3$ and thermal diffusivity = 0.8 cm $^2$/s. The cutting speed is 4.5 m/s, uncut chip thickness is 0.25 mm, and width of cut is 2.2 mm. The cutting force is measured at 1170 N. Using Cook's equation, determine the cutting temperature if the ambient temperature = 22°C.

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**Dr. Vincent Musonda** **18th September 2021**