Department of Mechanical Engineering
Indian Institute of Technology Kharagpur

End Semester Examination April 2012
Machine Tools and Machining (ME30604)
Duration: 3 hours **3rd Year all Students of ME + MF + IEM + Backlog** Full Marks: 100

Attempt any 10 questions
Questions with multiple parts (a, b, c etc.) need to be answered continuously

1 a The diameter of a circular disc of low carbon steel of 5 mm width is being reduced by a broad nose parting off tool at a constant cutting velocity of 120 m/min and feed of 0.1 mm/rev. The chip flows along the machine transverse plane. The main cutting force and the radial thrust force are 1000 N and 700 N respectively. The orthogonal rake angle is 6^0. The chip thickness is 0.2 mm. Calculate the following: (i) principal cutting edge angle (ii) inclination angle (iii) shear angle and (iv) dynamic yield shear strength 4

1 b Determine the ratio of specific cutting energy to the dynamic yield shear strength of a ductile work material subjected to orthogonal turning if the orthogonal rake angle is 0^0. Start with the basic equation $P_s = \frac{\tau_s tS}{\sin \beta_o}$ and the Merchant's circle diagram. 6

2 A low carbon steel bar of 200 mm diameter is being orthogonally turned. The density, thermal conductivity and specific heat are respectively 7800 kg/m^3, 50 W/m-K and 500 J/kg-K. The depth of cut, feed and cutting velocity are 4 mm, 0.25 mm/rev and 120 m/min respectively. It has been estimated that the rise in primary shear zone temperature is 250^0 C. 10% of the heat generated at the primary shear zone is taken away by the work piece and 100% conversion of energy due to plastic deformation at the primary shear zone takes place to heat energy. The orthogonal rake angle is 10^0. The master line of the rake surface is perpendicular to the machine longitudinal axis and it is also parallel to the main or principal cutting edge. The chip thickness is 0.40 mm. Calculate the following: (i) principal cutting edge angle (ii) shear angle (iii) rate of heat generation at the shear plane (iv) ratio of friction force to the normal force (v) shear velocity (vi) shear force (vii) resultant cutting force (viii) main cutting force (ix) dynamic yield shear strength and (x) specific cutting energy. 10

3 A semi-ductile steel bar of 200 mm diameter is being orthogonally turned. The depth of cut, feed and cutting velocity are 4 mm, 0.25 mm/rev and 120 m/min respectively. The dynamic yield shear strength is related to the normal stress at the primary shear zone as, $\tau_s = \tau_0 + 0.31\sigma_n$. The uncut chip thickness and chip thickness are 0.25 mm and 0.5 mm respectively. The angle between the friction force vector and the main cutting force vector (when shown in Merchant's circle diagram) is 80^0. The specific cutting energy is 1 GJ/m^3. Calculate the following: (i) 10

orthogonal rake angle (ii) principal cutting edge angle (iii) shear angle (iv) friction angle (η) (v) cutting power (vi) main cutting force (vii) resultant thrust force (P_{XY}) (viii) radial thrust force (P_Y) (ix) shear force and (x) dynamic yield shear strength.

4 The friction force, the normal force at the chip tool interface, the main cutting force and the resultant cutting force (P_{XY}) vectors form a rectangle on Merchant's circle diagram. The chip reduction coefficient is 2. The dynamic yield shear strength of the work material is 700 MPa. The depth of cut, feed and cutting velocity are 4 mm, 0.25 mm/rev and 120 m/min respectively. The ratio of the resultant thrust force and the main cutting force is 0.84. Calculate the following: (i) shear angle (ii) orthogonal rake angle (iii) friction angle (iv) shear force (v) resultant cutting force (vi) main cutting force (vii) friction force (viii) the cutting power (ix) the material removal rate and (x) specific cutting energy. 10

5 A low carbon steel bar of 200 mm diameter is being turned. The depth of cut, feed and cutting velocity are 1.0 mm, 0.25 mm/rev and 100 m/min respectively. The cutting tool is specified as: (-10^0 8^0 6^0 7^0 15^0 75^0 1.2 mm (ORS)). Find out the chip deviation angle with respect to the machine longitudinal plane 10

6 A circular disc of 200 mm diameter and 50 mm internal diameter is being faced in a centre lathe at a cutting speed of 100 m/min. The spindle speed has been set with respect to the outer diameter. The depth of cut and the feed are 1 mm and 0.1 mm/rev. Neglect approach and overtravel. 10

(i) Calculate machining or cutting time.

(ii) Also calculate the machining or cutting time if the same facing operation is undertaken in a CNC lathe with constant cutting velocity of 100 m/min without changing the depth of cut and feed.

(iii) Calculate material removal rate and volume of material removal for facing in a CNC lathe

(iv) Determine the ratio of volume of material removal to the material removal rate and comment by comparing your answer with the answer of Q.6(ii).

7 (i) Using suitable block diagram exhibit the primary difference between a metric and a BSW feed gearboxes. 2

(ii) The pitch of the lead screw of a centre lathe is 6 mm. A metric thread of 2 mm pitch is required to be machined. The transmission ratios of the change gear quadrant and Meander drive are both 0.5. The output of the meander is directly connected to the lead screw. If the numbers of teeth on the gears in Tumbler (connected to the Norton cone) are both 36, determine the number of teeth on the matching gear on the Norton Cone. 3

(iii) The apron constant is 100. The pinion in mesh with the rack has 18 number of teeth with a module of 1.5 mm. The spindle speed is 500 rpm. The transmission ratios of the change gear quadrant, Norton cone, Meander drive are 0.25, 0.75 and 2, respectively. The output of the Meander is directly 5 attached to the feed rod. Calculate the longitudinal feed in mm/rev, the same (longitudinal) feed in mm/min and the rotational speed of the feed rod in rpm.

8 (i) CNC machines can operate under a constant cutting speed mode. Name two turning operations where this capability is useful. 2

(ii) A two pane door must be opened and closed automatically using a single motor. Sketch a suitable mechanism. 2

(iii) Sketch any two speed reversal mechanisms 6

9 A single point turning tool is being used for turning. The principal cutting edge angle is less than 90^0. It has been seen that the chip flows at angle of θ from the orthogonal plane towards the work piece as measured on reference plane. Determine the rake angle (let us denote this by γ_θ) as measured on a plane perpendicular to the reference plane containing the chip flow direction in terms of relevant angles of orthogonal rake system (ORS). 10

10 (i) "Application of coolant at high pressure promotes better cooling in machining" – explain 10

(ii) How does application of lubricant help in temperature control in machining?

(iii) From composition point of view bring out the difference between K10 and P10 carbide inserts.

(iv) K10 inserts are used for finish turning of cast iron whereas K40 inserts rough turning of cast iron bars. From these requirement points of view, bring out the difference in composition between K10 and K40 carbide inserts.

11 Taylor tool life equation for P30 uncoated carbide and that for a TiC coated carbide while machining C-20 steel are given by 10

$VT^{0.3}=600$ and $VT^{1.3}=6000$ where V and T have their usual meaning.
Which cutting tool will give better tool life?

12 (a) State the significance of chip equivalent. What may be the modification in the geometry of a turning tool required to enhance MRR by increasing feed and depth of cut at constant chip equivalent? 3

(b) Draw suitable sketches to show the difference between nose radius and edge rounding radius of a turning tool. Which one of these two has stronger influence on specific cutting energy? 3

(c) Why is K grade carbide tool not recommended for machining low carbon steel? 2

(d) Can P grade carbide tool be used for machining grey cast iron? 2