Department of Mechanical Engineering
Indian Institute of Technology Kharagpur

End Semester Examination April 2013

Machine Tools and Machining (ME30604)

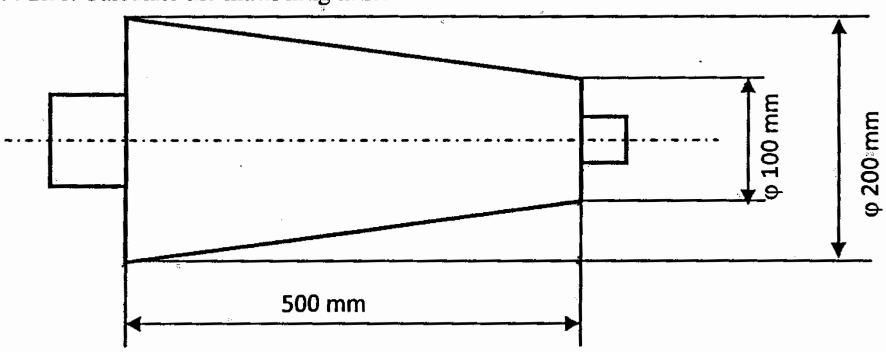
Duration: 3 hours Full Marks: 100

3rd Year all Students of ME + MF + IEM + Backlog

Answers to all numerical questions should be written in the appropriate place of the given paper and the paper should be submitted along with the manuscript. No marks will be awarded if a "copy-paste" error is committed either for numerical values or units.

Attempt any ten (10) questions

1 (a)	The plane A (π_A) of single point turning tool (being used in a centre lathe) is at an angle θ from the auxiliary cutting plane towards the operator as measured on the reference plane. The same plane (π_A) is orthogonal to the reference plane and it is in between the orthogonal plane and auxiliary cutting plane. Find out the expression of the rake angle as measured on π_A as a function of orthogonal rake, inclination angle of the principal cutting edge and other relevant tool angles **using graphical method.**	6
1 (b)	The following is a turning tool designation. One of the following angles is wrong. Identify. γ_x γ_y α_x α_y' ϕ_e ϕ r inch	2
1 (c)	The following is the designation of a turning tool (−6° −7° −8° 9° 60° 30° 1 mm ORS). One of the above angles is NOT feasible. Identify.	2
2 (a)	A right handed single point turning tool with zero nose radius has a principal cutting edge angle 60° and an auxiliary cutting edge angle of 30°. The inclination angles of the principal and auxiliary cutting edges are zero degree and −6° (minus six degrees) respectively. Show the tool in top view and show the master line of the rake surface. **You may use the manuscript for the sketch.**	4
2 (b)	Derive the relationships for (i) the angle between the master line of the rake surface and the machine longitudinal direction with side and back rake, and (ii) maximum rake with side and back rake of a right handed single point turning tool.	6
3 (a)	During turning, it is observed that the chip flows along the orthogonal plane. The cutting tool does not have any nose radius. The principal cutting edge angle is 60^0. The cutting velocity, feed and depth of cut, respectively, are 120 m/min, 0.2 mm/rev and 1 mm. The cutting plane and auxiliary cutting plane intersect each other at 90^0 as measured on reference plane. Find out the inclination angle of the principal cutting edge.	6
3 (b)	Derive an expression for cutting strain.	4
4	A semi ductile work material of 200 mm diameter is being orthogonally turned at a feed of 0.2 mm/rev, depth of cut of 2 mm and cutting velocity of 120 m/min. The machining constant as per Ernst and Merchant's 2nd solution (C) is 81^0. The specific cutting energy (neglecting the contribution of feed force towards cutting power) is 1.5 GJ/m^3. The angle between the resultant cutting force vector (R) and the shear force vector is 51^0. The main cutting edge of the cutting tool is along the machine transverse plane (π_y). The side rake is -10^0. *Note that Kronenberg's equation cannot be used.* Determine the following: i. orthogonal rake angle ii. principal cutting edge angle iii. shear angle iv. friction angle v. chip thickness vi. main or tangential cutting force vii. resultant thrust force (P_{xy}) viii. power required for feeding the cutting tool ix. shear force x. dynamic yield shear strength	10

5	A single point turning tool of geometrical specification (0^0 0^0 6^0 7^0 15^0 90^0 0.4 mm ORS) is being used to orthogonally turn a work material at a feed of 0.2 mm/rev, depth of cut of 2.5 mm and cutting velocity of 120 m/min. The cutting strain has been observed to be 2.7. The ratio of (longitudinal) feed force to main cutting force is 0.8. The dynamic yield shear of the work material is 600 MPa. *Note that Kronenberg's equation cannot be used.* Determine the following: i. shear angle ii. friction angle iii. chip thickness iv. width of cut v. shear force vi. resultant cutting force (*R*) vii. main or tangential cutting force viii. (radial) thrust force ix. cutting power (neglecting the contribution of feed force towards cutting power) x. specific cutting energy	10
6	The rise in shear plane temperature while orthogonally turning a ductile work material has been 200^0 C. The density, thermal conductivity and specific heat of the work material are 7800 kg/m^3, 47 W/m-K and 500 J/kg-K, respectively. 10% of the shear plane heat enters the workpiece and no energy remains stored as residual strain energy within the chip or the workpiece. The cutting velocity, feed and depth of cut are 120 m/min, 0.25 mm/rev and 4 mm, respectively. The cutting velocity vector and the chip velocity vector are orthogonal to each other. The shear angle is 26.5^0. *Note that Kronenberg's equation cannot be used.* Determine the following: i. chip reduction coefficient ii. chip velocity iii. orthogonal rake angle iv. shear velocity v. rate of heat generation at the shear plane vi. shear force vii. main cutting force viii. cutting power (neglecting the contribution of feed force towards cutting power) ix. rate of heat generation at the chip-tool interface x. friction force	10
7 (a)	A pre-forged bar of length of 500 mm is being taper turned in a CNC lathe with a constant cutting speed of 100 m/min with a depth of cut of 2 mm and a feed of 0.2 mm/rev. Assume overtravel and approach to be zero. Calculate the machining time.  	6
7 (b)	A 200 mm diameter circular bar is to be reduced to 196 mm by turning in a single pass. The length of the bar is 1000 mm. Assume: cutting velocity 80 m/min, feed 0.1 mm/rev, tool changing time 1 min, tool life 20 min, and idle time 2 min. Determine the machining time.	4
8 (a)	Taylors tool life equation for an **uncoated steel cutting grade carbide tool** is found to be $V_cT_L^{0.5}=500$ {where V_C is in m/min and T_L (tool life) is in minutes}. This tool is used at 100 m/min cutting velocity. For this cutting velocity, life of a **TiC coated carbide tool** is 100% higher. Also equivalent cutting velocity of the coated tool (i.e, the velocity at which it yields a tool life equal to the uncoated one) is	8

	found to be 200 m/min. Derive the tool life equation for the TiC coated tool. Calculate the break-even cutting velocity, if any, for these tools.	
8 (b)	Plot the variation of tool life with cutting velocity **on a single graph** for HSS and uncoated carbide inserts while turning medium carbon steel. **You may use the manuscript.**	2
9 (a)	A lathe with a **British lead screw** of pitch of 6 TPI is being used to machine a **metric thread of 4 mm.** Write a possible change gear arrangement in $\frac{Z_A}{Z_B} \times \frac{Z_C}{Z_D}$ format assuming the transmission ratios of both Tumbler-Norton Cone and Meander Drive to be 1.	2
9 (b)	BSW threads of the series 8, 9, 10, 11, 12 and 14 TPI are to be cut in a centre lathe having 6 mm pitch lead screw. Show (using a sketch) the input and output of the Norton drive with number of teeth in the gear cone and that in the sliding gear of the tumbler drive. Show also the gearing arrangement in the quadrant connecting the lathe spindle and the Norton drive. Minimum and maximum number of teeth of any gear is restricted to 17 and 130 respectively. **Use the manuscript for the sketches.**	8
10	(i) What type of carbide inserts is suitable for cutting cast iron? Write its nominal chemical composition. (ii) State any four criteria for machinability. (iii) Name any two techniques of toughening cutting tools. (iv) State any two differences between P10 and P40 grade of uncoated carbide insert. (v) Name any two mechanisms of crater wear development while turning low carbon steel with uncoated carbide insert. **You may use the manuscript.**	10
11	A HSS tool having 0°, 0°, 10°, 10°, 20°, 60°, 0 mm (ISO) is engaged in straight turning of C20 steel under the following conditions: Cutting velocity: 30 m/min Feed: 0.2 mm/rev Depth of cut: 2 mm Environment: dry The radial thrust force is required to be reduced by 20% without affecting the following: i) MRR ii) Average chip-tool interface temperature iii) Theoretical surface roughness of the workpiece Suggest with justification a suitable modification of the geometry of the principal cutting edge.	