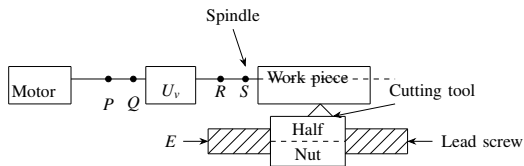
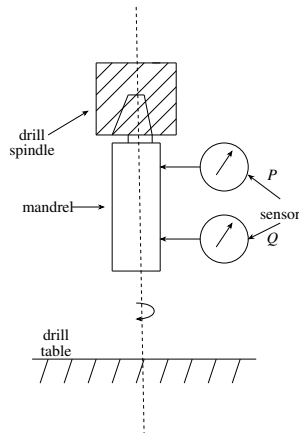


- 1) The figure shows an incomplete schematic of a conventional lathe to be used for cutting threads with different pitches. The speed gear box  $U_v$  is shown and the feed gear box  $U_s$  is to be placed.  $P, Q, R$  and  $S$  denote locations and have no other significance. Changes in  $U_v$  should **NOT** affect the pitch of thread being cut and changes in  $U_s$  should **NOT** affect the cutting speed.



The correct connections and the correct placement of  $U_s$  are given by (2008-ME)

- $Q$  and  $E$  are connected.  $U_s$  is placed between  $P$  and  $Q$
  - $S$  and  $E$  are connected.  $U_s$  is placed between  $R$  and  $S$
  - $Q$  and  $E$  are connected.  $U_s$  is placed between  $Q$  and  $E$
  - $S$  and  $E$  are connected.  $U_s$  is placed between  $S$  and  $E$
- 2) A displacement sensor (a dial indicator) measures the lateral displacement of a mandrel on the taper hole inside a drill spindle. The mandrel axis is an extension of the drill spindle taper hole axis and the protruding portion of the mandrel surface is perfectly cylindrical. Measurement are recorded as  $R_x$  = maximum deflection minus minimum deflection, corresponding to sensor position at  $X$ , over one rotation.



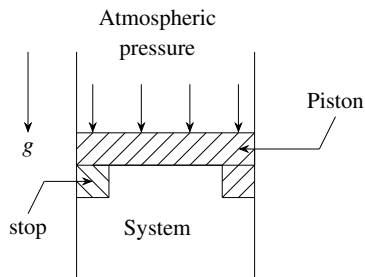
If  $R_P = R_Q > 0$  which one of the following would be consistent with the observation?  
(2008-ME)

- a) The drill spindle rotational axis is coincident with the drill spindle taper hole axis
- b) The drill spindle rotational axis intersects the drill spindle taper hole axis at the point  $P$
- c) The drill spindle rotational axis is parallel to the drill spindle taper hole axis
- d) The drill spindle rotational axis intersects the drill spindle taper hole axis at point  $Q$

## Common Data Questions

### Common Data for Questions 71, 72 and 73

In the figure shown, the system is a pure substance kept in a piston- cylinder arrangement. The system is initially a two- phase mixture containing  $1\text{kg}$  of liquid and  $0.03\text{kg}$  of vapour at a pressure of  $100\text{kPa}$ . Initially, the piston rests on a set of stops, as shown in the figure. A pressure of  $200\text{kPa}$  is required to exactly balance the weight of the piston and the outside atmospheric pressure. Heat transfer takes place into the system until its volume increases by  $50\%$ . Heat transfer to the system occurs in such a manner that the piston, when allowed to move, does so in a very slow (quasi-static / quasi-equilibrium) process. The thermal reservoir from which heat is transferred to the system as a temperature of  $400^\circ\text{C}$ . Average temperature of the system boundary can be taken as  $175^\circ\text{C}$ . Heat transfer to the system is  $1\text{kJ}$ , during which its entropy increases by  $10\text{J/K}$



Specific volume of liquid ( $v_f$ ) and vapour ( $v_g$ ) phases, as well as values of saturation temperatures, are given in the table below.

Pressure(kPa)	Saturation temperature $T_{sat}$ ( $^\circ\text{C}$ )	$v_f(\text{m}^3/\text{kg})$	$v_g(\text{m}^3/\text{kg})$
100	100	0.001	0.1
200	200	0.0015	0.002

- 3) At the end of the process, which one of the following situations will be true?  
(2008-ME)

- a) superheated vapour will be left in the system

- b) no vapour will be left in the system  
 c) a liquid + vapour mixture will be left in the system  
 d) the mixture will exist at dry saturated vapour state
- 4) The work done by the system during the process is (2008-ME)
- a)  $0.1kJ$                       b)  $0.2kJ$                       c)  $0.3kJ$                       d)  $0.4kJ$
- 5) The net entropy generation (considering the system and the thermal reservoir together) during the process is closest to (2008-ME)
- a)  $7.5J/K$                       b)  $7.7J/K$                       c)  $8.5J/K$                       d)  $10J/K$

### Common Data for the Questions 74 and 75

Consider the Linear Programme (LP)

Max  $4x + 6y$   
 subjects to  
 $3x + 2y \leq 6$   
 $2x + 3y \leq 6$   
 $x, y \geq 0$

- 6) After introducing slack variables  $s$  and  $t$ , the initial basic feasible solution is represented by the table below (basic variables are  $s = 6$ ,  $t = 6$  and the objective function value is 0 ). (2008-ME)

	-4	-6	0	0	0
$s$	3	2	1	0	6
$t$	2	3	0	1	6
	$x$	$y$	$s$	$t$	RHS

After some simplex iterations, the following table is obtained

	0	0	0	2	12
$s$	$\frac{5}{3}$	0	1	$-\frac{1}{3}$	2
$y$	$\frac{2}{3}$	1	0	$\frac{1}{3}$	2
	$x$	$y$	$s$	$t$	RHS

From this, one can conclude that

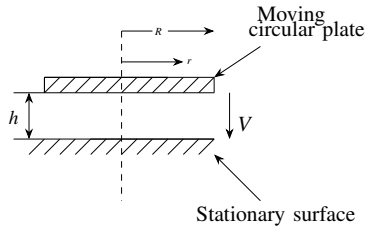
- a) The LP has a unique optimal solution  
 b) The LP has an optimal solution that is not unique  
 c) The LP is infeasible  
 d) The LP is unbounded
- 7) The dual for the LP in Q 74 is (2008-ME)

- a) Min  $6u + 6v$   
subject to  
 $3u + 2v \geq 4$   
 $2u + 3v \geq 6$   
 $u, v \geq 0$
- b) Max  $6u + 6v$   
subject to  
 $3u + 2v \leq 4$   
 $2u + 3v \leq 6$   
 $u, v \geq 0$
- c) Max  $4u + 6v$   
subject to  
 $3u + 2v \leq 4$   
 $2u + 3v \leq 6$   
 $u, v \geq 0$
- d) Min  $4u + 6v$   
subject to  
 $3u + 2v \leq 6$   
 $2u + 3v \leq 6$   
 $u, v \geq 0$

**Linked Answer Questions: Q.76 to Q.85 carry two marks each.**

**Statement for Linked Answer Questions 76 and 77:**

A cylindrical container of radius  $R = 1m$ , wall thickness  $1mm$  is filled with water upto a depth of  $m$  and suspended along with its upper rim. The density of water is  $1000kg/m^3$  and acceleration due to gravity is  $10m/s^2$ . The self weight of the cylinder is negligible. The formula for hoop stress in a thin walled cylinder can be used at all points along the height of the cylindrical container.



- 8) The axial and circumferential stress ( $\sigma_a, \sigma_c$ ) experienced by the cylinder wall at mid-depth (  $1m$  as shown) are (2008-ME)
- a)  $(10, 10) MPa$       b)  $(5, 10) MPa$       c)  $(10, 5) MPa$       d)  $(5, 5) MPa$
- 9) If the Young's modulus and Poisson's ratio of the container material are  $100GPa$  and  $0.3$ , respectively. The axial strain in the cylinder wall at mid height is (2008-ME)
- a)  $2 \times 10^{-5}$       c)  $7 \times 10^{-5}$   
b)  $6 \times 10^{-5}$       d)  $1.2 \times 10^{-5}$

**Statement for Linked Answer Questions 78 and 79:**

A steel bar of  $10mm \times 50mm$  is cantilevered with two  $M12$  bolts (  $P$  and  $Q$ ) to support a static load of as shown in figure aside.

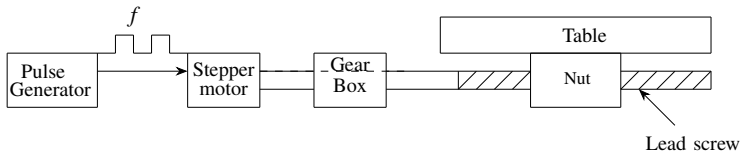


0.2mm/rev depth of cut is 3cm chip thickness ratio is 0.5 The orthogonal rake angle is  $7^\circ$ . Apply Merchants theory for analysis.

- 14) The shear plane angle (in degrees) and the shear force respectively are (2008-ME)
- a)  $22.65^\circ; 150N$  c)  $28^\circ; 400N$   
b)  $22.65^\circ; 320N$  d)  $28^\circ; 320N$
- 15) The cutting and frictional forces respectively are (2008-ME)
- a)  $568N; 387N$  c)  $202N; 120N$   
b)  $565N; 381N$  d)  $202N; 356N$

### Statement for Linked Answer Questions 84 and 85

In the feed drive of a point to point open loop drive, a stepper motor rotating at drives a table through a gear box and lead screw-nut mechanism (pitch =  $4\text{mm}$ , number of starts ). The gear ratio ( $= \frac{\text{Output rotational speed}}{\text{Input rotational speed}}$ ) is given by  $U = \frac{1}{4}$ . The stepper motor (driven by voltage pulses from a pulse generator) executes 1 step / pulse from a pulse generator) executes step / pulse of the generator. The frequency of the pulse train from the pulse generator is  $f = 10,000$  pulses per minute.



- 16) The basic length unit (*BLU*) , i.e. the table movement corresponding to 1 pulse of the pulse generator (2008-ME)
- 0.5 microns
  - 5 microns
  - 50 microns
  - 500 microns
- 17) A customer insists on a modification to change the *BLU* of the *CNC* drive to 10 microns without changing the table speed. The modification can be accomplished by (2008-ME)
- changing  $U$  to  $\frac{1}{2}$  and reducing  $f$  to  $\frac{f}{2}$
  - changing  $U$  to  $\frac{1}{8}$  and increasing  $f$  to  $2f$
  - changing  $U$  to  $\frac{1}{2}$  and keeping  $f$  to  $2f$
  - keeping  $U$  unchanged and increasing  $f$  to  $2f$