CLASS TEST

S.No. : 03DLSKME_IJKLMN_070826

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MACHINE TOOLS+METROLOGY+AUTOMATION

MECHANICAL ENGINEERING

Date of Test : 07/07/2026

ANSWER KEY

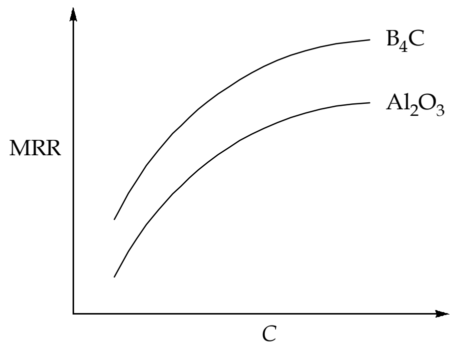
1.	(a)	7.	(a)	13.	(b)	19.	(b)	25.	(a)
2.	(d)	8.	(c)	14.	(a)	20.	(d)	26.	(b)
3.	(c)	9.	(b)	15.	(a)	21.	(b)	27.	(a)
4.	(c)	10.	(a)	16.	(b)	22.	(c)	28.	(b)
5.	(c)	11.	(c)	17.	(a)	23.	(b)	29.	(b)
6.	(b)	12.	(c)	18.	(c)	24.	(b)	30.	(b)

DETAILED EXPLANATIONS

1. (a)

In USM the variation of material removal rate (MRR) with respect to the volume concentration of abrasive in water slurry is governed by:

$$\text{MRR} \propto \frac{c^{1/4}A^{1/4}F^{3/4}a_0^{3/4}d_g f}{\sigma_w^{3/4}(1+\lambda)^{3/4}}\mu^{3/4}$$



Volume concentration of abrasive slurry, C

2. (d)

α = 10°, γ = 0.4

$$\tan\phi = \frac{0.4\cos 10°}{(1-0.4\sin 10°)}$$

$$\phi = 22.94°$$

Now applying Merchant theory,

$$\phi = 45° + \frac{\alpha}{2} - \frac{\beta}{2}$$

$$22.94° = 45° + \frac{10°}{2} - \frac{\beta}{2}$$

$$\beta = 54.12°$$

$$\mu = \tan\beta = \tan 54.12° = 1.38$$

3. (c)

4. (c)

M-code	**Description**
M-03	Spindle ON clockwise
M-06	Tool change
M-09	Coolant OFF
M-98	Call sub-program

5. (c)

STL file format is represented by interaction of lines and triangles. An STL file represents a surface geometry using facets. The facets define the surface of the 3-D object and is uniquely identified by a unit normal, which is a line perpendicular to triangle with length of one and by three vertices.

6. (b)

Approach angle, $\lambda = 75°$

Side cutting edge angle, $C_s = 90° - \lambda$

$= 90° - 75° = 15°$

Mean surface roughness, $R_a = 3\ \mu m$

$= 3 \times 10^{-3}$ mm

Maximum height of roughness, $H_{max} = 4\ R_a$

$= 4 \times 3 \times 10^{-3} = 12 \times 10^{-3}$ mm

As we know,

$$H_{max} = \frac{f}{\tan C_s + \cot C_e}$$

$$12 \times 10^{-3} = \frac{0.07}{\tan 15 + \cot C_e}$$

$$\tan 15 + \cot C_e = 5.8333$$

$$\cot C_e = 5.5654$$

$$\Rightarrow \quad C_e = 10.186°$$

So, end cutting edge angle, $C_e = 10.186°$

7. (a)

8. (c)

Number of degrees of freedom restricted = 9

Number of degrees of freedom free = 3

$$\text{Ratio} = \frac{9}{3} = 3$$

9. (b)

For minimum power,

$$2\phi + \beta - \alpha = 90°$$

$$\Rightarrow \quad \beta - \alpha = 20° \qquad [\because \phi = 35°]$$

$$\tan(\beta - \alpha) = \frac{F_T}{F_c} = \tan 20°,$$

$$\therefore \quad \frac{F_c}{F_T} = 2.747$$

10. (a)

G90 - Absolute coordinate system.

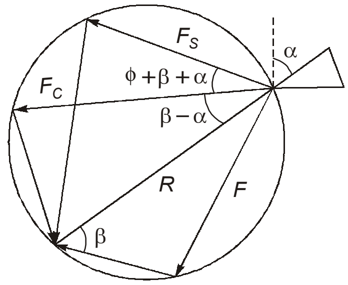
G91 - Incremental coordinate system.

Coordinates of P_2 is Absolute positioning is (20, 10, 0).

Coordinates of P_2 is incremental positioning is (10, –10, 0).

11. (c)

By Merchant's theory



$$\frac{F_c}{F_s} = \frac{R\cos(\beta-\alpha)}{R\cos(\phi+\beta-\alpha)}$$

$$\alpha = 7°$$

$$\beta = ?$$

$$\phi = ?$$

$$\tan\phi = \frac{r\cos\alpha}{1-r\sin\alpha} = \frac{0.5\cos 7°}{1-0.5\sin 7°}$$

$$\phi = 27.8553°$$

$$2\phi = 90 + \alpha - \beta$$

$$2 \times 27.8553 = 90 + 7 - \beta$$

$$\beta = 41.2892°$$

$$F_s = \frac{\tau_s bt}{\sin\phi} = \frac{250\times 3\times 0.2}{\sin 27.8553°} = 321.0340 \text{ N}$$

$$F_c = 321.0340 \times \frac{\cos(41.2892-7)}{\cos(41.2892+27.8553-7)}$$

$$F_c = 567.66 \text{ N}$$

12. (c)

$$\text{Transformation matrix} = \begin{bmatrix} \cos 90° & -\sin 90° & 0 \\ \sin 90° & \cos 90° & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\Rightarrow \quad \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 4 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 4 \\ 1 \end{bmatrix}$$

New coordinate $B' = (0, 4)$

$$\Rightarrow \quad \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 2 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} -2 \\ 2 \\ 1 \end{bmatrix}$$

New coordinate $C' = (-2, 2)$

13. (b)

Given: $VT^{0.2} = 520$

When, $V_1 = 220\text{ m/min}$

$$T_1 = \left(\frac{520}{220}\right)^5 = 73.7739\text{ minutes}$$

$$V_2 = 120\text{ m/min}$$

$$V_1(T_1')^n = V_1(T_2)^n$$

$$220 \times (73.7739 - 30)^{0.2} = 120 \times T_2^{0.25}$$

or $T_2 = 906.62\text{ min}$

$$\text{Total tool used} = 30 + 906.62$$
$$= 936.62\text{ min}$$
$$\simeq 937\text{ min}$$

Alternatively,

Given: $VT^{0.2} = 520$

When, $V = 220\text{ m/min}$

$$T = \left(\frac{520}{220}\right)^5 = 73.7739\text{ minutes}$$

When, $V = 120\text{ m/min}$

$$T = \left(\frac{520}{120}\right)^5 = 1527.954\text{ minutes}$$

Fraction of tool life used when machining at 220 m/min = $\dfrac{30}{73.7739}$

$$\text{Fraction of tool life left} = 1 - \frac{30}{73.7739} = 0.5933$$

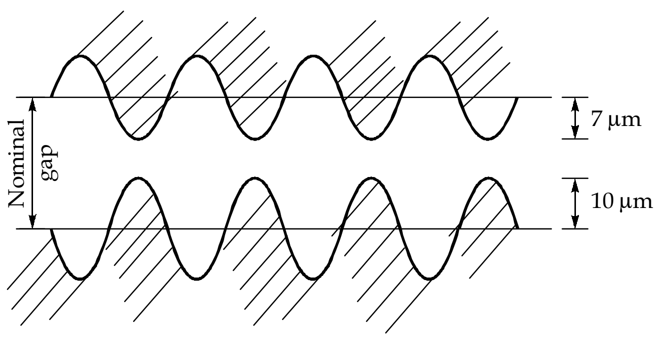
For the fresh tool, tool life at 120 m/min = 1527.954

For the old tool, tool life at 120 m/min = 0.5933 × 1527.954

$$= 906.61\text{ minutes}$$

$$\text{Total time of machining} = 30 + 906.61$$
$$= 936.61 \approx 937\text{ minutes}$$

14. (a)



$$\text{Gap }(h) = 7 + 10 = 17\ \mu\text{m} = 17 \times 10^{-4}\text{ cm}$$

$$R = \rho_e \frac{L}{A} = \frac{1}{0.25}\Omega\text{ cm} \times \frac{17 \times 10^{-4}\text{ cm}}{A\text{ cm}^2}$$

$$= \frac{17 \times 10^{-4}}{0.25A}\Omega$$

$$I = \frac{V - \Delta V}{R} = \frac{(15-1.5)\times 25A}{17\times 10^{-4}}\text{Amp}$$

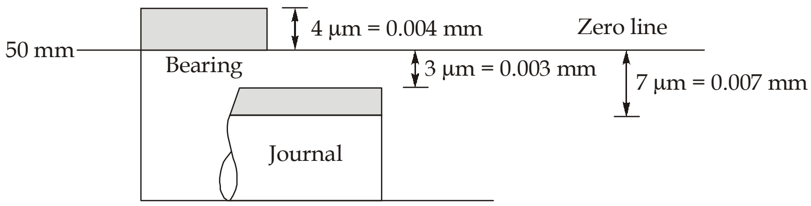
Now,

$$\text{MRR} = \frac{AI}{\rho_s VF} = 55.85\times\left(\frac{13.5\times 0.25A}{17\times 10^{-4}}\right)\times\frac{1}{7.86\times 3\times 96500}\ \text{cm}^3/\text{sec}$$

$$\text{MRR} = Af = \frac{AI}{\rho_s VF} = 55.85\times\left(\frac{13.5\times 0.25A}{17\times 10^{-4}}\right)\times\frac{1}{7.86\times 3\times 96500}\ \text{cm}^3/\text{sec}$$

$$f = 0.0487 \text{ cm/sec}$$

15. (a)



$$\text{Allowance} = \text{Min } C = 3\ \mu\text{m}$$

16. (b)

$$VT^n = C$$

$$V_1T_1^n = C$$

$$V_2T_2^n = C$$

$$\frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^n$$

$\therefore$
$$n\log_e\left(\frac{T_2}{T_1}\right) = \log_e\left(\frac{V_1}{V_2}\right)$$

$\therefore$
$$n = \frac{\log_e\left(\frac{100}{130}\right)}{\log_e\left(\frac{50}{120}\right)} = 0.2996$$

$$V_1T_1^{0.2996} = C$$

$\Rightarrow$
$$C = 100 \times (120)^{0.2996} = 419.684$$

So,
$$V_{80} = \frac{419.85}{(80)^{0.2996}} = 112.96 \text{ m/min}$$

$$V_{80} = 1.88 \text{ m/s}$$

17. (a)

Given: Idle time, t_c = 500 μs; V_0 = 100 V

V_d = 70 V; C = 100 μF

Charging resistance, R_C = ?

Charging time or idle time,

$$t_c = R_C \cdot C \ln\left(\frac{V_0}{V_0 - V_d}\right)$$

$$500 \times 10^{-6} s = R_C \times 100 \times 10^{-6} \ln\left(\frac{100}{100-70}\right)$$

$$\Rightarrow \quad R_C = 4\ \Omega$$

18. (c)

$$t = f \sin\lambda = 0.4 \sin 60° = 0.346 \text{ mm}$$

$$r = \frac{t}{t_c} = \frac{0.346}{0.8} = 0.43$$

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.43\cos 15°}{1 - 0.43\sin 15°} = 0.467$$

$$\phi = \tan^{-1}(0.467) = 25°$$

$$\text{Shear strain, } \gamma = \tan(\phi - \alpha) + \cot\phi$$

$$= \tan(10°) + \cot 25°$$

$$= 2.321$$

$$\text{Shear strain rate, } \dot{\gamma} = \frac{\cos\alpha}{\cos(\phi - \alpha)} \times \frac{V}{\Delta y} = \frac{\cos 15°}{\cos 10°} \times \frac{150/60}{9 \times 10^{-6}}$$

$$= 2.7 \times 10^5 \text{ s}^{-1}$$

19. (b)

$$\text{BLU (mm/pulse)} = \frac{\alpha}{360} \times P \times \frac{1}{4}$$

$$= \frac{3.6}{360} \times 3 \times \frac{1}{4} = 7.5 \times 10^{-3} \text{ mm}$$

$$\text{Table speed, } V = 18 \text{ mm/s}$$

$$\text{Pulse frequency (pulse/second)} = \frac{V}{(BLU)}\frac{(mm/s)}{(mm/pulse)}$$

$$= \frac{18}{7.5 \times 10^{-3}} = 2400 \text{ Hz}$$

20. (d)

Taylor's principle of gauging

- A Go gauge will check all the dimension of the work piece in the maximum metal condition (indicating the presence of the greater amount of material permitted at a prescribed surface). It should check the size of the component also the geometrical shape.
- NOT GO gauges will check only one dimension of the work piece at a time, for the minimum metal conditions (indicating the presence of the least amount of material permitted at a prescribed surface.)

In case of hole, the maximum metal condition is obtained when the hole is machined to the low limit of size, and minimum metal condition results when the hole is made to the high limit of size.

21. **(b)**

$$D = \sqrt{18 \times 30} = 23.2379 \text{ mm}$$

$$\text{Upper deviation of shaft} = -5.5(23.2379)^{0.41} \ \mu\text{m}$$

$$= -19.975 \ \mu\text{m}$$

$$= -0.019975 \text{ mm}$$

$$\text{Higher limit of shaft} = 20 - 0.019975 = 19.980 \text{ mm}$$

22. **(c)**

$$N_{min} = \frac{1000 \times v}{\pi \times D_{max}} = \frac{1000 \times 16}{\pi \times 24} = 212.206 \text{ rpm}$$

$$N_{max} = \frac{1000 \times v}{\pi \times D_{min}} = \frac{1000 \times 16}{\pi \times 8} = 636.619 \text{ rpm}$$

$$N_{max} = N_{min} \times r^{n-1}$$

$$\Rightarrow \quad 636.619 = 212.206 \times r^5$$

$$r^5 = 3$$

$$r = 1.2457$$

23. **(b)**

Total material removal rate,

$$\text{MRR} = \frac{\pi}{4} D_1^2 f_m + \frac{\pi}{4} D_2^2 f_m$$

$$= \frac{\pi}{4} f_m \left(D_1^2 + D_2^2\right)$$

$$\Rightarrow \quad \frac{\pi}{4} \times \left(13^2 + 19^2\right) \times f_m = 24580$$

$$f_m = 59.049 \text{ mm/min}$$

Compulsory approach for drill 1, $x_1 = \dfrac{D_1/2}{\tan\dfrac{\alpha}{2}} = \dfrac{13/2}{\tan 59^\circ} = 3.905$ mm

Compulsory approach for drill 2, $x_2 = \dfrac{D_2/2}{\tan\dfrac{\alpha}{2}} = \dfrac{19/2}{\tan 59^\circ} = 5.708$ mm

$$\text{Time required to drill hole 1} = \frac{L + x_1}{f_m} = \frac{40 + 3.905}{59.049} \times 60 = 44.612 \text{ seconds}$$

$$\text{Time required to drill hole 2} = \frac{L + x_2}{f_m} = \frac{40 + 5.708}{59.049} \times 60 = 46.44 \text{ seconds}$$

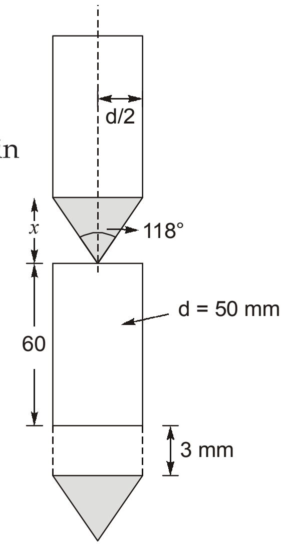
$$= 46.44 \text{ seconds}$$

As both the drill are working simultaneously so the time for the complete operation is 46.44 seconds.

24. **(b)**

25. **(a)**

$$V = 70 \text{ m/min}$$
$$D = 50 \text{ mm}$$
$$f = 0.25 \text{ mm/rev}$$
$$L = 60 \text{ mm}$$



Spindle speed, $N = \dfrac{1000V}{\pi D} = \dfrac{1000 \times 70}{\pi \times 50} = 445.633 \text{ rev/min}$

Breakthrough distance,

$$A = \frac{50}{2 \tan 59°}$$
$$A = 15.02 \text{ mm}$$

Total length of drill travel, $L = 60 + 15.02 + 3$

$$L = 78.02 \text{ mm}$$

Time for drilling the hole $= \dfrac{78.02}{0.25 \times 445.633} = 0.7 \text{ min}$

26. **(b)**

$$\text{TC} = C_m T_m + C_m \times \frac{T_i}{N} + C_e \frac{T_m}{T} + C_m \left(\frac{T_m}{T}\right) T_C$$

$$= 20 \times 2 + 20 \times \frac{120}{100} + 100\left(\frac{2}{10}\right) + 20\left(\frac{2}{10}\right)4$$

$$= 40 + 24 + 20 + 16$$

$$\text{TC} = ₹100/\text{piece}$$

27. **(a)**

$$\frac{n\lambda}{2} = BC; \frac{BC}{L} = \tan\delta\theta = \delta\theta$$

$$\frac{n\lambda}{2} = L \times \delta\theta \qquad BC = L \times \delta\theta$$

$$\frac{20 \times 5 \times 10^{-10}}{2} = 5 \times 10^{-3}\,\delta\theta$$

$$\delta\theta = 10 \times 10^{-7} = 1\ \mu \text{ degree}$$

28. (b)

$$x_{max} = 2f_t\sqrt{\frac{d}{D}\left(1-\frac{d}{D}\right)}$$

$$d = 3 \text{ mm}, D = 150 \text{ mm},$$

$$f_t = \text{Feed per tooth}$$

$$f_t = \frac{10}{10} = 1 \text{ mm/teeth}$$

$$x_{max} = 2\times 1\sqrt{\frac{3}{150}\left(1-\frac{3}{150}\right)}$$

$$x_{max} = 0.28 \text{ mm}$$

29. (b)

Given: $R = 200\ \Omega$, $C = 50 \times 10^{-6}$ F, $t_2 = 0.05\ t_1$

$$\text{Cycle time, } t = t_1 + t_2$$

$$V_d = V_o\left(1-e^{-t/RC}\right)$$

$$0.72V_o = V_o\left(1-e^{-t/RC}\right)$$

$$\Rightarrow \quad 0.72 = 1-e^{\frac{-t}{200\times 50\times 10^{-6}}}$$

$$e^{-\frac{t}{0.01}} = 0.28$$

$$-\frac{t}{0.01} = \ln(0.28)$$

$$\text{Cycle time, } t = 12.73 \times 10^{-3} \text{ sec}$$

$$\therefore \quad t = 12.73 \text{ ms}$$

$$t = t_1 + t_2$$

$$12.73 = t + 0.05t$$

$$t = 12.124 \text{ ms}$$

30. (b)

$$N(\text{rpm}) = \frac{60f_p}{n_s} = \frac{60\times 10000}{300} = 2000 \text{ rpm}$$

$$\text{Gear ratio} = \frac{1}{4}$$

$$\text{rpm pf lead screw} = \frac{2000}{4} = 500 \text{ rpm}$$

$$\text{In one rev of lead screw} = 9 \text{ mm linear movement}$$

$$1 \text{ mm of linear movement} = \frac{1}{9}\text{ rev.}$$

$$6 \text{ mm of linear movement} = \frac{6}{9}\text{ rev.}$$

$$\text{Time consumed in } \frac{6}{9}\text{ rev.} = \frac{6/9}{500}\text{ min} = \frac{6\times 60}{9\times 500}\text{ sec} = \frac{6\times 60}{9}\times 2 \text{ milli second} = \frac{240}{3} = 80 \text{ ms}$$

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