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MACHINE TOOLS+METROLOGY+AUTOMATION

MECHANICAL ENGINEERING

Date of Test : 07/04/2026

ANSWER KEY >

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

DETAILED EXPLANATIONS

1. (d)

2. (a)

Reading on the main scale upto zero of the vernier scale = 35.5 mm

The number of graduation that coincides with the graduation on the main scale = 20th

Main scale graduations = 24

Value of one division = 0.5 mm

Each division on vernier scale = $\frac{24 \times 0.5}{25} = 0.48$ mm

Least count LC = 0.5 - 0.48 = 0.02 mm

Total reading = 35.5 + 20 × 0.02

= 35.5 + 0.4 = 35.90 mm

3. (c)

∴ Size of NO-GO gauge = upper limit of hole

= 42.0 + 0.2 mm = 42.2 mm

4. (b)

Depth of square thread = $\frac{\text{pitch}}{2} = \frac{12}{2} = 6$ mm

Depth of thread to give a clearance of 0.14 mm = 6 + 0.14 = 6.14 mm

5. (d)

$$V \times (5 \times 60)^{0.16} = 100 \times (45)^{0.16}$$

$$V = 73.82 \text{ m/min}$$

$$\text{Spindle speed} = \frac{73.82 \times 1000}{\pi \times 25} = 939.90543 \text{ rev/min}$$

$$\text{Cutting time per piece} = \frac{50 \times 60}{939.90543 \times 0.25} = 12.7672 \text{ sec}$$

No. of components per tool change

$$= \frac{5 \times 60 \times 60}{12.7672} = 1409.858 = 1410$$

6. (a)

Cross-sectional area of the chip

= depth of cut × feed per revolution

$$= 2.00 \times \frac{1}{(\text{No. of cuts per mm})}$$

$$= 2 \times \frac{1}{5} = 0.4 \text{ mm}^2$$

Pressure of the chip cross-sectional area on the tool

$$\begin{aligned}
 &= \frac{2000}{0.4 \times 10^{-6}} = 5000 \times 10^6 \\
 &= 5 \times 10^9 \text{ N/m}^2 \\
 &= 5 \text{ kN/mm}^2
 \end{aligned}$$

7. (b)

$$\text{Machining time} = \frac{L}{f_t \times Z \times N}$$

$$\text{Approach distance, } A = \sqrt{d(D-d)} = \sqrt{2(100-2)} = 14 \text{ mm}$$

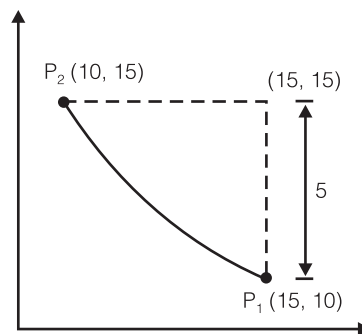
$$L = 150 + 2 \times 14 = 178 \text{ mm}$$

$$T = \frac{178}{0.15 \times 8 \times 65} = 2.28 \text{ min} = 2.28 \times 60 = 136.92 \text{ sec}$$

8. (c)

Given, $P_1 (15, 10)$

$P_2 (10, 15)$



Clearly from figure

Centre of arc having radius 5 is

$$(15, (10+5)) = (15, 15)$$

9. (b)

It is considered a group of automatic machine tools because it integrates the functions of several different machines into a single unit. This integration enables multiple machining operations to be performed efficiently within one system, reducing setup time and improving overall productivity in mechanical engineering applications.

10. (c)

Flexible Manufacturing System.

11. (b)

$$\text{Cutting speed, } v = \frac{\pi DN}{1000}$$

$$95 = \frac{\pi \times 20 \times N}{1000}$$

$$N = 1511.9719 \text{ rpm}$$

$$\text{Feed per min} = \text{Feed per tooth} \times \text{No. of teeth} \times \text{rpm}$$

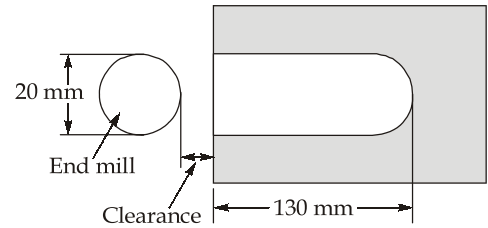
$$= 0.15 \times 5 \times 1511.9719 = 1133.97897 \text{ mm/min}$$

$$\text{Approach distance } A_D = \frac{D}{2} = \frac{20}{2} = 10 \text{ mm}$$

$$L = 130 + 10 = 140 \text{ mm}$$

$$\text{Cutting time} = \frac{140}{1133.97897} = 0.12345 \text{ min}$$

$$= 7.40 \text{ sec}$$



12. (c)

$$r = \frac{0.6}{0.8} = 0.75, \alpha = 15^\circ$$

$$\phi = \tan^{-1} \left(\frac{0.75 \cos 15^\circ}{1 - 0.75 \sin 15^\circ} \right)$$

$$\phi = 41.95^\circ$$

$$\frac{V}{\cos(\phi - \alpha)} = \frac{V_s}{\cos \alpha}$$

$$V_s = \frac{2.5 \times \cos 15^\circ}{\cos(41.95 - 15^\circ)} = 2.709 \text{ m/s}$$

$$\text{Shear strain rate } (\dot{\epsilon}) = \frac{V_s}{t_s} = \frac{2.709 \text{ m/s}}{25 \times 10^{-6} \text{ m}} = (1.0836 \times 10^5) \text{ sec}^{-1}$$

13. (b)

Side cutting edge angle, $C_s = 60^\circ$

End cutting edge angle, $C_e = 30^\circ$

Feed, $f = 0.08 \text{ mm}$

Maximum height of roughness

$$H_{\max} = \frac{f}{\tan C_s + \cot C_e} = \frac{0.08}{\tan 60^\circ + \cot 30^\circ}$$

$$= 0.023094 \text{ mm} = 23.094 \mu\text{m}$$

$$\text{Mean surface roughness, } R_a = \frac{H_{\max}}{4} = \frac{23.094}{4}$$

$$R_a = 5.773 \mu\text{m}$$

14. (a)

minimum hole size = 19.96 mm

maximum hole size = 20.06 mm

work tolerance = 0.1 mm

wear tolerance 0.01 mm = gauge tolerance

minimum NO GO gauge size = 20.06 - 0.01 (gauge tolerance)

$$= 20.05 \text{ mm}$$

15. (d)

$$r = \frac{t}{t_c} = \frac{0.21}{0.60} = 0.35$$

$$\phi = \tan^{-1} \left(\frac{r \cos \alpha}{1 - r \sin \alpha} \right) = \tan^{-1} \left(\frac{0.35 \cos 20^\circ}{1 - 0.35 \sin 20^\circ} \right)$$

$$\phi = 20.48^\circ$$

$$\begin{aligned} \text{Shear strain, } \gamma &= \cot \phi + \tan (\phi - \alpha) \\ &= \cot 20.48^\circ + \tan (20.48^\circ - 20^\circ) \\ \gamma &= 2.6858 \end{aligned}$$

16. (b)

$$\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} = \frac{0.383 \cos 15^\circ}{1 - 0.383 \sin 15^\circ} = 0.41$$

$$\phi = 22.34^\circ$$

$$\tan \beta = 0.7 \Rightarrow \beta = 35^\circ$$

$$\begin{aligned} F_C &= \text{Cutting force} = \frac{\tau_s b t}{\sec(\beta - \alpha) \cos(\phi + \beta - \alpha) \sin \phi} \\ &= \frac{280 \times 3 \times 0.5}{\sec(35^\circ - 15^\circ) \cos(22.34^\circ + 35^\circ - 15^\circ) \sin 22.34^\circ} \\ &= 1404.74 \text{ N} \end{aligned}$$

$$\tan(\beta - \alpha) = \frac{F_t}{F_c}$$

$$\begin{aligned} F_t &= F_c \times \tan (35^\circ - 15^\circ) \\ &= 1404.74 \times \tan (20^\circ) \\ &= 511.28 \text{ N} \end{aligned}$$

Tangential force on tool face = $F = F_c \sin \alpha + F_t \cos \alpha$

$$\begin{aligned} F &= 1404.74 \sin 15^\circ + 511.28 \cos 15^\circ \\ &= 857.432 \text{ N} \end{aligned}$$

17. (a)

$$V_1 T_1^n = V_2 T_2^n$$

$$\frac{\pi \times 20 \times 250}{1000} (40)^n = \frac{\pi \times 20 \times 320}{1000} (24)^n$$

$$\ln \left(\frac{320}{250} \right) = n \ln \left(\frac{40}{24} \right)$$

$$\ln 1.28 = n \ln(1.667)$$

$$n = 0.4832$$

$$V_1 T_1^n = V_3 T_3^n$$

$$\frac{\pi \times 20 \times 250}{1000} (40)^{0.4832} = \frac{\pi \times 20}{1000} \times N \times (30)^{0.4832}$$

$$N = 287.283 \text{ rpm}$$

18. (a)

$$\frac{\text{Friction energy}}{\text{Total energy}} = \frac{FV_C}{F_C V}$$

$$\frac{V_C}{V} = \frac{t}{t_c} = r$$

$$\frac{\text{Friction energy}}{\text{Total energy}} = \frac{F}{F_C} r$$

$$r = \frac{t}{t_c} = \frac{0.127}{0.229} = 0.5545$$

$$F = F_C \sin \alpha + F_t \cos \alpha = 556.25 \sin 10^\circ + 222.50 \cos 10^\circ \\ = 315.71 \text{ N}$$

$$\frac{\text{Friction energy}}{\text{Total energy}} = \frac{315.71 \times 0.5545}{556.25} = 0.31471$$

19. (c)

$$\text{Machining time, } t_m = \frac{L}{V_f} = \frac{\text{Machining length}}{\text{Feed velocity}}$$

$$L = L_w + A + O + C$$

A = Approach, O = Overrun, L_w = Length of workpiece, C = Cone height

$$C = \frac{D}{2 \tan \beta} = \frac{25}{2 \times \tan 60^\circ} \quad (\text{where, } \beta = \text{Semicone angle})$$

$$C = 7.2168 \text{ mm}$$

$$L = 60 + 2 + 2 + 7.2168 = 71.2168 \text{ mm}$$

$$\text{Cutting speed, } V = \pi D N$$

$$N = \frac{V}{\pi D} = \frac{60 \times 1000}{\pi \times 25} = 763.943 \text{ rpm}$$

So, $V_f = f \times N = 0.25 \times 763.943 = 190.985 \text{ mm/min}$

So, $t_m = \frac{71.2168}{190.985} = 0.378 \text{ min} = 22.6875 \text{ second}$

20. (a)

$$D = \sqrt{18 \times 30} = 23.238 \text{ mm}$$

$$i = 0.45 \sqrt[3]{D} + 0.001 D = 0.45 \sqrt[3]{23.238} + 0.001 \times 23.238 = 1.31 \text{ microns}$$

$$\text{Fundamental tolerance} = 25i = 25 \times 1.31$$

$$= 32.68 \text{ microns}$$

for hole 'H', fundamental deviation = 0

So, Upper limit of hole is = 25 + 0.03268 = 25.033 mm

21. (b)

$$\text{Contact strip length, } L = \sqrt{R \Delta h} = \sqrt{500 \times (1 - 0.8) \times 25} = 50 \text{ mm}$$

$$\text{True strain, } \epsilon = \ln \left(\frac{25}{20} \right) = 0.223$$

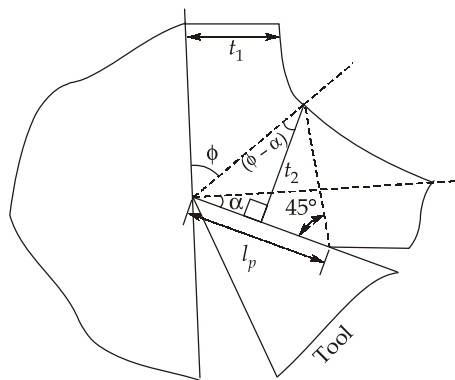
$$\text{Average flow stress, } \sigma_f = \frac{k \epsilon^n}{n+1}$$

(where, k is strength coefficient and n is the strain hardening exponent)

$$\text{Average flow stress, } \sigma_f = \frac{250 \times (0.223)^{0.2}}{1.2} = 154.32 \text{ MPa}$$

$$\begin{aligned} \text{Rolling torque, } T &= Fa = \sigma_f \times bL \times \frac{L}{2} \\ &= 154.32 \times \frac{250}{1000} \times \frac{50}{1000} \times \frac{50}{2000} \times 10^3 \\ &= 48.225 \text{ kN-m} \end{aligned}$$

22. (b)



From figure:
$$l_p = t_2 \tan(\phi - \alpha) + t_2 \tan 45^\circ$$

Shear angle (ϕ):
$$\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha}$$

where,
$$r = \text{Chip thickness ratio} = \frac{t_1}{t_2} = \frac{f \sin \lambda}{0.6} = \frac{0.32 \sin 75^\circ}{0.6} = 0.515$$

$$\tan \phi = \frac{0.515 \cos 10^\circ}{1 - 0.515 \sin 10^\circ} = 0.557$$

$$\phi = 29.125^\circ$$

So,
$$\begin{aligned} l_p &= 0.6 \tan (29.125 - 10)^\circ + 0.6 \tan 45^\circ \\ &= 0.808 \text{ mm} = 0.81 \text{ mm} \end{aligned}$$

23. (b)

Given
$$\begin{aligned} t_m &= 10 \text{ min, } f = ? \text{ mm/stroke} \\ B &= 100 \text{ mm, approach} = \text{overtravel} = 5 \text{ mm} \end{aligned}$$

$$\Rightarrow B_{\text{eff.}} = 100 + 5 + 5 = 110 \text{ mm}$$

$$\Rightarrow L = 140 \text{ mm, } V = 25 \text{ m/min, } \lambda = 0.67$$

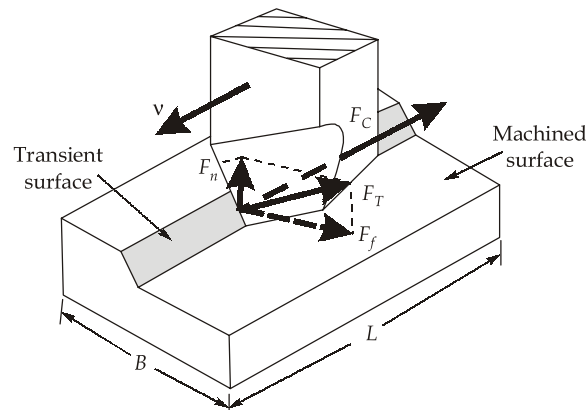
$$N = \frac{V}{L(1+\lambda)} = \frac{25 \times 10^3}{140 \times 1.67}$$

$$\Rightarrow N = 106.93 \text{ stroke/min}$$

$$t_m = \frac{B_{\text{eff.}}}{fN} = \frac{110}{f \times 106.93} = 10 \text{ minutes}$$

⇒ $f = 0.1028 \text{ mm/stroke}$

24. (b)



Components of machining force during shaping

$$\beta = \tan^{-1} \mu$$

(where, β is the friction angle and μ is the coefficient of friction)

$$\beta = \tan^{-1} (0.6)$$

$$\beta = 30.96^\circ$$

We know that,

$$\begin{aligned} F_T &= F_C \tan(\beta - \alpha) \\ &= 1090 \tan(30.96 - 10) \\ &= 417.538 \text{ N} \end{aligned}$$

So, Feed force,

$$F_f = F_T \sin \lambda = 417.538 \times \sin 60^\circ = 361.59 \text{ N}$$

Normal force,

$$F_n = F_T \cos \lambda = 417.538 \times \cos 60^\circ = 208.77 \text{ N}$$

25. (c)

We know that, ideal surface finish in turning is

$$R_{\max} = \frac{f}{\cot \lambda + \cot C_e} \quad (\text{where, } f \text{ is feed}).$$

λ = principal cutting edge angle and C_e = end cutting edge angle

So, lower the R_{\max} , higher the surface finish and it can be achieved by decreasing principal cutting edge angle and end cutting edge angle both.

26. (a)

27. (b)

$$2\alpha = 118^\circ \Rightarrow \alpha = 59^\circ$$

$$D = 30 \text{ mm}$$

$$\text{Break through, } A = \frac{D}{2 \tan \alpha} = \frac{30}{2 \tan 59^\circ} = 9.0129 \text{ mm}$$

Total length of tool travel, $L = L + A + C$

l = Length of hole = 100 mm

$A = 9.0129 \text{ mm}$

$C = 0$ as the drill touches the surface

$L = 100 + 9.0129 = 109.0129 \text{ mm}$

$$\text{Time for drilling the hole} = \frac{L}{fN} \text{ minutes} = \frac{109.0129 \times \pi \times 30}{0.22 \times 60 \times 333.33} = 2.335 \text{ minutes} \approx 140 \text{ seconds}$$

28. (d)

$$H_{\max} = \frac{f}{\tan \psi + \cot \gamma}$$

$$\psi = 15^\circ, \gamma = 5^\circ$$

$$H_{\max} = \frac{0.1}{\tan 15^\circ + \cot 5^\circ} = \frac{0.1}{0.268 + 11.43} \text{ mm} = \frac{0.1 \times 10^3}{11.698} \mu\text{m} = 8.5485 \mu\text{m}$$

29. (b)

Rate of metal removal (MRR) = Speed \times Feed \times Depth of cut

$$= V_w b d = 0.3 (1.2 \times 10^{-3}) (0.05 \times 10^{-3}) = 0.018 \times 10^{-6} \text{ m}^3/\text{s}$$

Required power = Specific cutting energy \times MRR

$$= 40 \times 10^9 \times 0.018 \times 10^{-6}$$

$$= 720 \text{ Nm/s} = 720 \text{ W}$$

Power = Tangential force \times Wheel speed = $F_h \times V_g$

$$F_h = \frac{720}{30} = 24 \text{ N}$$

30. (b)

Shear strain, $\gamma = \cot \phi + \tan \phi$

Shear plane angle, $\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} = r$ (for $\alpha = 0^\circ$)

$$\text{Cutting ratio, } r = \frac{0.24}{0.58} = 0.4138$$

$$\phi = \tan^{-1}(r) = \tan^{-1}(0.4138) = 22.48^\circ$$

$$\begin{aligned} \text{Shear strain, } \gamma &= \frac{1}{\tan 22.48^\circ} + \tan 22.48^\circ \\ &= 2.4166 + 0.4138 = 2.83 \end{aligned}$$

