Important Questions *for* **GATE 2022**

MECHANICAL ENGINEERING

MADE EASY

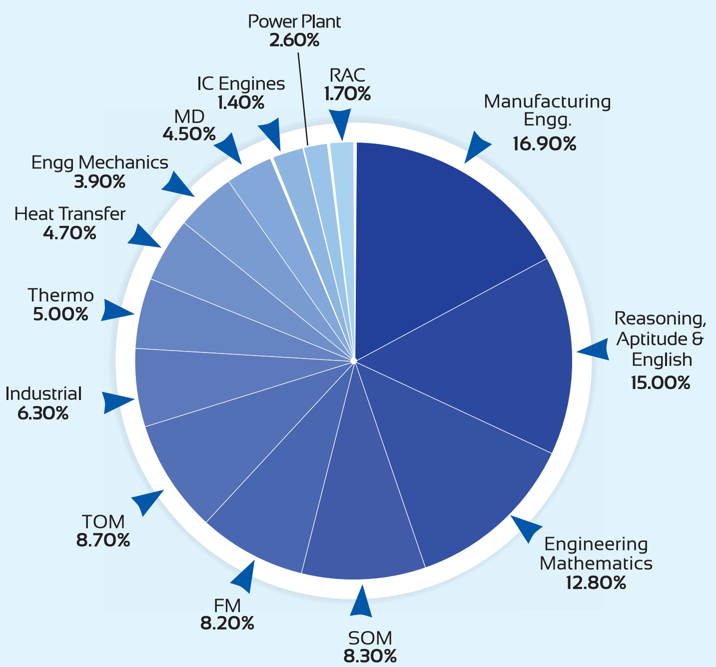
India's Best Institute for IES, GATE & PSUs

Day 2 of 8

Q.26 - Q.50 (Out of 200 Questions)

Production Engineering + RAC

SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Manufacturing Engineering	16.90%
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	12.80%
Strength of Materials	8.30%
Theory of Machines	8.70%
Fluid Mechanics & Hydraulic Machines	8.20%
Industrial Engineering	6.30%
Thermodynamics	5.00%
Heat Transfer	4.70%
Engineering Mechanics	3.90%
Machine Design	4.50%
Internal Combustion Engines	1.40%
Power Plant Engineering	2.60%
Refrigeration & Air Conditioning	1.70%
Total	**100%**

Production Engineering + RAC

Q.26 A 6 m × 6 m × 4 m room contains air at 25°C and 100 kPa at a relative humidity of 75 percent. The enthalpy per unit mass of the dry air is _______ kJ/kg of dry air. [Take P_{sat} at 25°C = 3.1698 kPa]. [Correct upto 2 decimal placs]

Q.27 A refrigerator is working between the temperature limits of 25°C and –5°C. At the entry of the compressor, dryness fraction is 0.6. Mass flow rate of refrigerant in the cycle is 0.167 kg/s. The power input required by the compressor is_____.

Temp.(°C)	Specific enthalpy of saturated liquid (kJ/kg)	Latent enthalpy (kJ/kg)	Specific entropy of saturated liquid (kJ/kg-K)
25	81.25	121.6	0.2513
–5	–7.53	245.8	–0.0419

(a) 18 kW (b) 10.5 kW
(c) 63 kW (d) 3 kW

Q.28 An air refrigeration system works on reversed Brayton cycle and is used for 10 tonnes of refrigeration capacity. Air enters the compressor at –20°C and 1.4 bar and compressed to 4.2 bar. Compressed air is cooled in the cooler to 50°C with a loss in pressure of 0.2 bar. The theoretical piston displacement of the compressor is (Take γ = 1.4 and c_p = 1.005 kJ/kgK.)
(a) 1.0617 m^3/min (b) 63.7 m^3/min
(c) 79.1 m^3/min (d) 50 m^3/min

Q.29 An air refrigerator working on Bell Coleman cycle takes atmospheric air into the compressor at –5°C and compresses it polytropically with $PV^{1.35} = C$ upto 5 bar and cools to 25°C at the same pressure. It is further expanded isentropically in the expander to 1 bar. The isentropic efficiency of expander is 90%. The net work required is _________ kJ/kg. (Correct upto three decimal places)

Q.30 In NH_3-water absorption system the heat is supplied to generator by condensing steam at 0.2 MPa. The initial state of the steam is at a dryness fraction of 0.9 and the final state of steam after condensing is saturated liquid. The temperature to be maintained in refrigerator is –10°C and surrounding temperature is 30°C. If relative efficiency is 0.4 and refrigeration load is 20 TR, the steam flow rate is ______ kg/s. [Given: At 0.2 MPa, T_{sat} = 120°C and h_{fg} = 2201.9 kJ/kg]. [Correct upto 3 decimal places]

Q.31 In an ammonia refrigerator, saturated NH_3 at 2.3637 bar enters a 15 cm × 15 cm twin cylinder, single acting compressor running at 250 rpm. The clearance ratio for compressor is 0.04. The condenser pressure is 11.671 bar and temperature at exit of compressor is 372 K. The NH_3 circulated in cycle is _____kg/min. [Correct upto 2 decimal places]

Pressure, P (bar)	Saturation temp.(°C)	Specific volume of vapour at saturation (m^3/kg)	Enthalpy of liquid at saturation (kJ/kg)	Enthalpy of vapour at saturation (kJ/kg)
2.3637	–15	0.50905	131.28	1444.19
11.671	30	0.11048	342.08	1485.93

Q.32 Saturated ammonia at 0.23571 MPa enters a single acting compressor and liquid ammonia at 21°C enters the expansion valve of a refrigerating plant.

If head pressure is 1.1638 MPa, then the COP of the refrigerating cycle is ____. [Correct upto 1 decimal places]

Given: C_P (Liquid NH_3) = 4.6 kJ/kgK ; C_P (Vapour NH_3) = 2.75 kJ/kgK

P (MPa)	Sat. temp. (°C)	Sp. Vol. of vapour (m^3/kg)	Enthalpy of liquid NH_3 (kJ/kg)	Enthalpy of vapour NH_3 (kJ/kg)	Entropy of liquid NH_3 (kJ/kg)	Entropy of vapour NH_3 (kJ/kg)
0.23571	– 15°C	0.5106	168.54	1481.52	5.4387	10.526
1.1638	+30°C	0.11084	379.3	1523.42	6.1853	9.9606

Q.33 Two 7 mm thick steel plates are placed 5 mm apart and welded by a butt joint. Welding is carried out at 20 Volts. Heat transfer efficiency is 80% and melting efficiency is 60%. If the heat required to melt steel is 12 J/mm^3 and heat required to melt steel per second is 2100 J, then the welding current is ________Ampere.

Q.34 A resistance seam welding operation is performed on two pieces of 5 mm thick aluminium sheets. The specific melting energy for aluminium is 2.9 J/mm^3. The process parameters are: current = 6000 A and welding duration = 0.3 s, interface resistance = 75 μΩ. The electrode wheels have a diameter of 250 mm. The individual weld nuggets formed are 6 mm in diameter and 3 mm thick. Assume the weld nuggets are cylindrical in shape and are continuous to form a sealed seam. The power unit driving the process requires an off-time between spot welds is 1 s. The fraction of energy generated that goes into the formation of each weld nugget and the rotational speed (in rpm) of the electrode wheels is, respectively

(a) 0.3, 0.35
(b) 0.3, 0.455
(c) 0.15, 0.35
(d) 0.15, 0.455

Q.35 A cube, a sphere and a cylinder (h/d = 1) made of cast iron having same volume were casted under identical conditions. If solidification times for cube, sphere and cylinder were t_c, t_s and t_{cyl}, respectively, then

(a) $t_c : t_s : t_{cyl} = 0.65 : 1 : 0.76$
(b) $t_c : t_s : t_{cyl} = 0.76 : 1 : 0.65$
(c) $t_c : t_s : t_{cyl} = 1.31 : 1 : 1.54$
(d) $t_c : t_s : t_{cyl} = 1.54 : 1 : 1.31$

Q.36 The dimensions of a cylindrical top riser (h/d = 1), which is to be used to feed steel casting 30 cm × 30 cm × 10 cm are to be determined. Casting is poured horizontally into the mould. Using modulus method, the diameter of the riser is __________ cm.

Q.37 Resistance welding is used to make lap joint with a current of 15000 amp for 0.5s. Joint is assumed to be cylindrical in shape of diameter 4 mm and height 1.5 mm. The effective resistance of joint is 100 μΩ. The density of metal is 7.8 g/cm^3. The heat lost to the surrounding if heat required to melt sheet is 1795 kJ/kg is _______ kJ.

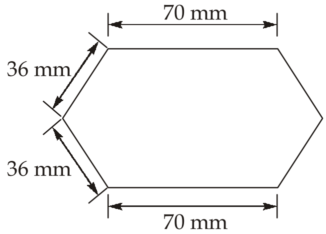
Q.38 Steel piping is to be produced by centrifugal casting. The length is 4 m, the inner diameter is 1 m, and the thickness is 20 mm. Using basic equations from dynamics and statics. The rotational speed needed to have the centripetal force as 80 times its weight will be_____.

(a) 374.6 rpm
(b) 174.6 rpm
(c) 39.46 rpm
(d) 354.1 rpm

Q.39 A critical dimension in casting of plain carbon steel is 29 mm which has to be maintained. If master pattern is made up of aluminium. Calculate the dimension of wooden pattern, which is to be used for making the aluminium pattern. Given shrinkage allowance for aluminium is 13 mm/m and for plain carbon steel is 21 mm/m.

(a) 39.986 mm
(b) 92.896 mm
(c) 29.994 mm
(d) 10.986 mm

Q.40 If the component is made up of a sheet which is 1.5 mm thick and it has a shear strength of 295 MPa then the punching load required for the component as shown in figure, is_____kN.



Q.41 The higher limit of a 20 f 8 shaft with following data is_______ mm. [Correct upto 2 decimal places]

Given: i(microns) = $0.45\ D^{1/3} + 0.001D$

Upper deviation of f shaft (in microns) = $-5.5\ D^{0.41}$

20 mm falls in diameter step of 18 mm to 30 mm.

$$\text{IT7} = 16i$$

Q.42 Holes of diameter $20^{+0.060}_{+0.050}$ are to be electroplated. If the desired diameter of holes after plating is $20^{+0.030}_{+0.010}$, the plating thickness varies between

(a) 10 – 25 microns
(b) 15 – 20 microns
(c) 8 – 14 microns
(d) 16 – 20 microns

Q.43 Electrochemical machining is to be performed on iron block to remove a surface of 30 mm × 10 mm.

Following data are available:
Valency of Iron = 2
Atomic weight of Iron = 55.845
Faraday's constant = 96485
Density of Iron = 7.86 g/cm^3

If the desired material removal rate is 20 g/min, the current and electrode feed rate required to achieve this MRR is, respectively

(a) 9053 A, 6.67 cm/min
(b) 1152 A, 6.67 cm/min
(c) 9053 A, 0.848 cm/min
(d) 1152 A, 0.848 cm/min

Q.44 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	**List-II**
A. M05	**1.** Absolute coordinate system
B. G90	**2.** Point to point positioning
C. G00	**3.** Clockwise circular interpolation
D. G02	**4.** Spindle stop/off

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	4	1	2	3
(c)	3	2	4	1
(d)	3	2	1	4

Q.45 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	**List-II**
A. Abrasive jet machining	**1.** Melting and Vaporization
B. Laser beam machining	**2.** Brittle fracture
C. Electrochemical machining	**3.** Melting and cavitation
D. Electric discharge machining	**4.** Chemical dissolution

Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	1	2	4	3
(c)	2	1	3	4
(d)	1	2	3	4

Q.46 A circular disc of 400 mm diameter and 100 mm height is to forged to 50 mm height. If the materials follows the flow equation, $\sigma_f = 200\,(0.02 + \varepsilon)^{0.42}$ MPa, then flow stress is equal to __________ MPa. [Correct upto 1 decimal place]

Q.47 While removing material from iron having atomic weight 56, Valency 2 and density 7.9 g/cc by ECM, a metal removal rate of 3 cc/min is desired. The current (in Amp) required for achieving this material removal rate is________ [Correct upto 1 decimal place]

Q.48 Moist air at a pressure of 100 kPa is compressed to 500 kPa and then cooled to 35°C in a cooler at constant pressure. In cooling process there is no condensation, the air at the entry to the cooler is unsaturated and becomes just saturated at the exit of the cooler. The saturation pressure of vapour at 35°C is 5.628 kPa. The partial pressure of vapour (in kPa) in moist air entering the compressor is ________.

Multiple Select Question (MSQ)

Q.49 Which of the following statements is/are correct regarding refrigerant-absorbent used in vapour absorption refrigeration system?

(a) Water-lithium bromide systems are used for refrigeration applications above 0°C only.
(b) Ammonia-water systems can be used for refrigeration application below 0°C only.
(c) Small ammonia water systems are used in domestic refrigerators.
(d) Small water-lithium bromide systems are used in room air conditioners.

Q.50 Which of the following statements are true regarding welding?

(a) In autogenous welding, no filler material is added during joining.
(b) Grains become coarser due to annealing within heat affected zone.
(c) In soldering, lead-tin alloy is used as a filler material.
(d) In friction welding, melting of interface welds the joint.

■■■■

Detailed Explanation

26. 63.68 (63.50 to 63.80)

$$\omega = \frac{0.622\, P_v}{(P - P_v)}$$

$$P_v = \phi P_s = 0.75 \times 3.1698$$

$$= 2.377 \text{ kPa}$$

$$\therefore \quad \omega = \frac{0.622 \times 2.377}{(100 - 2.377)}$$

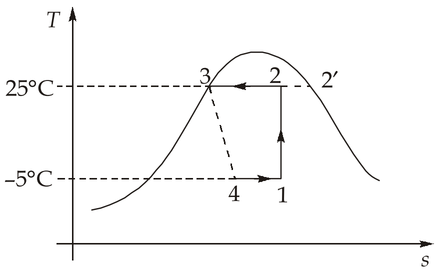
$$= 0.01514 \text{ kg of water vapour/kg dry air}$$

$$\therefore \quad h = 1.005t + \omega(2500 + 1.88\, t)$$

$$= 1.005 \times 25 + 0.01514\,(2500 + 1.88 \times 25)$$

$$h = 63.68 \text{ kJ/kg of dry air.}$$

27. (d)



Entropy at 1,

$$s_1 = (s_f)_{-5} + x(s_{fg})_{-5}$$

$$= -0.0419 + 0.6 \times \frac{245.8}{(273-5)}$$

$$s_1 = 0.5084 \text{ kJ/kgK}$$

Entropy at 2′, $$s_2' = 0.2513 + \frac{121.6}{(273+25)}$$

$$s_2' = 0.65935 \text{ kJ/kgK}$$

As $s_1 < s_2'$ and 1-2 process is isentropic process, so state 2 will lie in the wet region.

So, $$s_1 = s_2$$

$$(s_f)_{25} + \frac{x_2 (s_{fg})_{25}}{T} = s_1$$

$$0.2513 + x_2 \times \frac{121.6}{298} = 0.5084$$

$$x_2 = 0.63$$

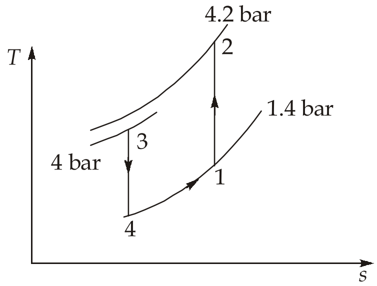
$$h_2 = (h_f)_{25} + x_2(h_{fg})_{25} = 81.25 + 0.63 \times 121.6$$

$$h_2 = 157.86 \text{ kJ/kg}$$

$$h_1 = (h_f)_{-5} + x \times (h_{fg})_{-5} = -7.53 + 0.6 \times 245.8 = 139.95 \text{ kJ/kg}$$

$$P_c = \dot{m}(h_2 - h_1)$$
$$= 0.167(157.86 - 139.95)$$
$$P_c = 2.99 \text{ kW} \simeq 3 \text{ kW}$$

28. (c)



As there is a loss in pressure in cooler,

$$P_3 = 4.2 - 0.2 = 4 \text{ bar}$$

3-4 is an isentropic expansion process,

$$\therefore \quad \frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{(\gamma-1)/\gamma}$$

$$T_4 = \frac{T_3}{\left(\frac{4}{1.4}\right)^{(\gamma-1)/\gamma}} \qquad [T_3 = 50 + 273 = 323 \text{ K}]$$

$$T_4 = 239.3 \text{ K}$$

Let $\dot{m}$ be the mass flow rate of air.

$$\text{So, Refrigeration capacity} = \dot{m} \times c_p(T_1 - T_4) \qquad [T_1 = 273 - 20 = 253 \text{ K}]$$

$$10 \times 3.5 = \dot{m} \times 1.005(253 - 239.3)$$

$$\dot{m} = 2.542 \text{ kg/s}$$

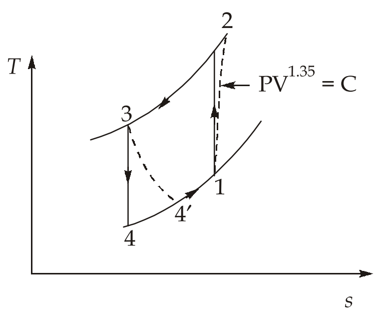
Theoretical piston displacement ($\dot{V}_1$),

$$P_1 \dot{V}_1 = \dot{m} R T_1$$

$$\dot{V}_1 = \frac{2.542 \times 0.287 \times 253}{1.4 \times 10^2}$$

$$\dot{V}_1 = 1.3184 \text{ m}^3/\text{s} = 79.104 \text{ m}^3/\text{min}$$

29. (54.265)(53 to 56)



$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(n-1)/n}$$

$$T_2 = T_1(5)^{1.35-1/1.35}$$

$$T_1 = -5 + 273 = 268 \text{K}$$

$$T_2 = 268(5)^{0.35/1.35}$$

$$T_2 = 406.77\text{ K}$$

$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{(\gamma-1)/\gamma}$$

$$T_4 = \frac{T_3}{(r_p)^{(\gamma-1)/\gamma}} \qquad [r_p = 5, \gamma = 1.4]$$

$$T_3 = 25 + 273 = 298\text{ K}$$

$$T_4 = \frac{298}{(5)^{0.4/1.4}}$$

$$T_4 = 1881.152\text{ K}$$

$$\eta_T = 0.9 = \frac{(T_3 - T_4')}{(T_3 - T_4)}$$

$$T_4' = 199.141\text{K}$$

$$W_{net} = W_C - W_T$$

$$W_C = \frac{n}{(n-1)}R(T_2 - T_1) = 153.618\text{ kJ/kg}$$

$$W_T = c_p(T_3 - T_4') = 99.35\text{ kJ/kg}$$

$$W_{net} = W_C - W_T = 153.618 - 99.35 = 54.265\text{ kJ/kg}$$

30. (0.058)(0.045 to 0.070)

Given: $x_1 = 0.9$

$$COP_{act} = \eta_{relative} \times COP_{max}$$

$$= 0.4 \times \frac{T_E(T_G - T_o)}{T_G(T_o - T_E)} = 0.4 \times \frac{263 \times (393 - 303)}{393 \times (303 - 263)}$$

$$COP_{act} = 0.6023$$

$$W_{act} = \frac{\dot{Q}_E}{\dot{Q}_g}$$

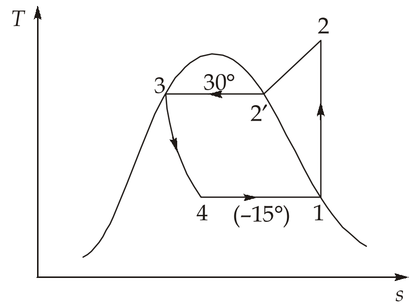
$$\Rightarrow \quad \dot{Q}_g = \frac{20 \times 3.5}{0.6023} = 116.22\text{ kW}$$

$$Q_{1\text{-}2} = h_1 - h_2 = 0.9 \times h_{fg} = 0.9 \times 2201.9 = 1981.71\text{ kJ/kg}$$

$$\dot{Q}_g = \dot{m} \times Q_{1-2}$$

$$\Rightarrow \quad \dot{m} = \frac{\dot{Q}_g}{Q_{1-2}} = 0.058\text{ kg/s}$$

31. **(2.2)(2.20 to 2.40)**



Process 2-3 is at constant pressure. Assuming ideal gas in super heated region. So,

$$\frac{v_2'}{T_2'} = \frac{v_2}{T_2}$$

$$\frac{0.11048}{303} = \frac{v_2}{372}$$

$$v_2 = 0.13563 \text{ m}^3/\text{kg} \quad (v_2' = \text{specific volume at saturated vapour at } 30°\text{C})$$

For compressor:

$$\eta_v = 1 + C - C\left(\frac{P_2}{P_1}\right)^{1/\eta_e} = 1 + C - C\left(\frac{v_1}{v_2}\right)$$

$$\eta_v = 1 + 0.04 - 0.04 \times \left(\frac{0.50905}{0.13563}\right)$$

$$\eta_v = 0.8898$$

$$\eta_v = \frac{m \times v_1}{\frac{\pi}{4} \times D^2 \times L \times N \times K}$$

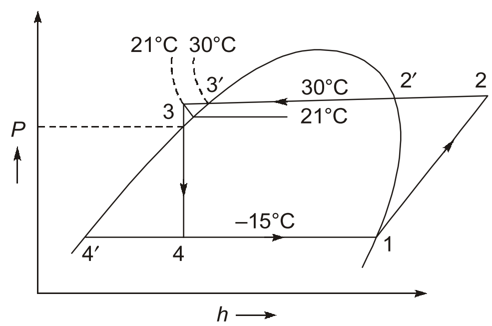
$$0.8898 \times \frac{\pi}{4} \times 0.15^2 \times 0.15 \times \frac{250}{60} \times 2 = mv_1$$

$$mv_1 = 0.019655 \qquad (v_1 = 0.50905 \text{ m}^3/\text{kg})$$

$$m = 0.038611 \text{ kg/s}$$

$$m = 2.3166 \text{ kg/min} \simeq 2.32 \text{ kg/min}$$

32. **(4.9)(4.8 to 5.2)**



$$s_1 = s_2$$

$$= s_2' + C_p \ln \frac{T_2}{T_2'}$$

$$\Rightarrow \quad 10.526 = 9.9606 + 2.75\, ln \frac{T_2}{303}$$

$$\Rightarrow \quad T_2 = 372 \text{ K}$$

$$h_2 = h'_2 + c_P (T_2 - T'_2)$$
$$= 1523.42 + 2.75 (372 - 303)$$
$$= 1713.17 \text{ kJ/kg}$$

Again,
$$h_3 = h'_3 - c_P (T'_3 - T_3)$$
$$= 379.3 - 4.6 (303 - 294) = 337.9 \text{ kJ/kg}$$
$$h_3 = 337.9 \text{ kJ/kg}$$

$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{1481.52 - 337.9}{1713.17 - 1481.52} = 4.94 \simeq 4.9$$

33. (218.75)(217 to 220)

Given:

Thickness of each plate, t = 7 mm

Distance between plates, d = 5 mm

Voltage, V = 20 volt

Heat transfer efficiency, η_H = 80%

Melting efficiency, η_m = 60%

Heat required for melting = 12 J/mm^3

Heat required per second for melting = 2100 J

Welding speed = v

We know that, welding current = I

Heat required per second for melting = $(t \times d) \times v \times 12$

$$2100 = (7 \times 5) \times (v) \times 12$$
$$v = 5 \text{ mm/s}$$

Heat energy supplied, $H_s = V \times I \times \eta_H = = 20 \times I \times 0.8$

$$H_s = 16I$$

$$\text{Melting efficiency, } \eta_m = \frac{\text{Heat required per second for melting}}{\text{Heat energy supplied}}$$

$$0.60 = \frac{2100}{16I}$$

$$I = \frac{2100}{16 \times 0.6} = 218.75 \text{ Ampere}$$

34. (a)

Given thickness, t = 5 mm

E = 2.9 J/mm^3; I = 6000A; t = 0.3 sec; R = 75 μΩ; D = 250 mm; d_w = 6 mm t_w = 3 mm

$$V_w = \frac{\pi}{4}(6)^2 \times 3 = 84.82 \text{ mm}^3$$

Energy generated during welding duration $E = I^2Rt$ = 810 J

Energy required for a weld in nugget E_w = 245.978 J

Fraction of energy generated that goes into the formation of each nugget

$$= \frac{E_w}{E} = \frac{245.978}{810} = 0.30$$

As diameter of nugget is 6 mm, the peripheral speed of electrode wheel will be 6mm/(1 + 0.3) secs .

As 1 sec is the off-time and N is the rotational speed (in rpm) then

$$\frac{\pi DN}{60} = \frac{6}{1.3} \text{ mm/sec}$$

$$\frac{\pi(250)N}{60} = \frac{6}{1.3}$$

$$N = 0.35 \text{ rpm}$$

35. (a)

$$\left(\frac{V}{SA}\right)_{\text{cube}} = \frac{a}{6}$$

$$\left(\frac{V}{SA}\right)_{\text{Sphere}} = \frac{d}{6}$$

$$\left(\frac{V}{SA}\right)_{\text{cylinder}} = \frac{\frac{\pi}{4}d^2h}{2\times\frac{\pi}{4}d^2 + \pi dh} = \frac{d}{6}$$

$$V_c = V_s = V_{\text{cyl}} \Rightarrow a^3 = \frac{4}{3}\pi r_s^3 = \frac{\pi}{4}d^3$$

$$\therefore \quad a = \left(\frac{4}{3}\pi\right)^{1/3} r_s \ , \ d = \left(\frac{16}{3}\right)^{1/3} r_s$$

$$\frac{t_{\text{cube}}}{t_{\text{sphere}}} = \frac{\left(\frac{V}{SA}\right)^2_{\text{cube}}}{\left(\frac{V}{SA}\right)_{\text{sphere}}} = \left(\frac{\left(\frac{4}{3}\pi\right)^{1/3} r_s}{2r_s}\right)^2 = 0.65$$

$$\frac{t_{\text{sphere}}}{t_{\text{cyl}}} = \left(\frac{d_s}{d}\right)^2 = \left(\frac{2r_s}{\left(\frac{16}{3}\right)^{1/3} r_s}\right)^2 = \frac{1}{0.76}$$

$$\therefore \quad t_c : t_s : t_{\text{cyl}} = 0.65 : 1 : 0.76$$

36. (18)(18 to 18)

Using modulus method,

$$m_r = 1.2\, m_c$$

and for cylindrical top riser, $m_r = \frac{D}{5}$

$$\therefore \quad D = 6\, M_c$$

$$= 6\left(\frac{V}{SA}\right)_C = 6\times\left(\frac{30\times30\times10}{2(30\times30 + 30\times10 + 10\times30)}\right) = 18 \text{ cm}$$

37. (10.986)(10 to 12)

Heat required to melt, $Q_R = \frac{\pi}{4} \times d^2 \times h \times \rho \times u$

$$Q_R = \frac{\pi}{4} \times 4^2 \times 1.5 \times 0.0078 \times 1795$$

$$= 263.912 \text{ J}$$

Heat supplied to weld, $Q_s = I^2Rt$

$$Q_s = (15000)^2 \times 100 \times 10^{-6} \times 0.5$$

$$= 11250 \text{ J}$$

Heat lost to the surrounding, $Q_{lost} = Q_s - Q_R$

$$Q_{lost} = 11250 - 263.912$$

$$= 10986.08 \text{ J} = 10.986 \text{ kJ}$$

38. (a)

Given: Inner diameter, d_i = 1 m = 1000 mm

Outer diameter, d_o = 1 m + 2 × 0.02 = 1.04 m = 1040 mm

Centripetal force, $F_c = mr\omega^2 = 80\,mg$

$$r\omega^2 = 80\,g \quad \text{...(1)}$$

Now, mean radius, $r = \frac{1}{2}\left[\frac{d_i + d_o}{2}\right] = \frac{1}{2}\left[\frac{1000+1040}{2}\right]$

Mean radius, r = 510 mm = 0.51 m

From eq. (1),

$$r\omega^2 = 80\text{g}$$

$$\omega^2 = \frac{80 \times 9.81}{0.510}$$

$$\omega^2 = 1538.82353$$

$$\omega = 39.228 \text{ rad/s}$$

$$\frac{2\pi N}{60} = 39.228$$

$$N = \frac{39.228 \times 60}{2\pi}$$

$$N = 374.6 \text{ rpm}$$

39. (c)

Dimension of wooden pattern $= 29 \times \left(1 + \frac{21}{1000}\right)\left(1 + \frac{13}{1000}\right) = 29.994$ mm

40. (125.67) (125 to 127)

Punching force, $F = Lt\tau$

where, L = 70 + 36 + 36 + 70 + 36 + 36 = 284 mm

$$F = 284 \times 1.5 \times 295$$

$$= 125670 \text{ N} = 125.67 \text{ kN}$$

41. **(19.98)(19.97 to 19.99)**

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

$$\text{Upper deviation of shaft} = -5.5(23.2379)^{0.41} \ \mu\text{m}$$
$$= -19.975 \ \mu\text{m}$$
$$= -0.019975 \text{ mm}$$
$$\text{Higher limit of shaft} = 20 - 0.019975 \approx 19.98 \text{ mm}$$

42. **(b)**

UL of D_i = 20.060 mm UL of D_f = 20.030 mm

LL of D_i = 20.050 mm LL of D_f = 20.010 mm

$$\text{LL of } D_f + 2t_{max} = \text{UL of } D_i$$
$$\Rightarrow \quad 20.010 + 2t_{max} = 20.050$$
$$\Rightarrow \quad t_{max} = 0.02 \text{ mm} = 20 \text{ microns}$$
$$\text{UL of } D_f + 2t_{min} = \text{UL of } D_i$$
$$20.030 + 2t_{min} = 20.060$$
$$\Rightarrow \quad t_{min} = 0.015 \text{ mm} = 15 \text{ microns}$$

Plate thickness varies between 15 – 20 microns.

43. **(d)**

$$\text{MRR} = \frac{eI}{F} = \frac{20}{60} = \frac{\left(\frac{55.845}{2}\right)I}{96485}$$

$$\Rightarrow \quad I = 1151.82$$
$$\simeq 1152 \text{ A}$$

$$f = \frac{MRR \times v}{A} = \frac{\left(\frac{MRR}{\rho}\right)}{A} = \frac{\left(\frac{20}{7.86}\right)}{\frac{30}{10} \times \frac{10}{10}} \text{ cm/min}$$
$$= 0.848 \text{ cm/min}$$

44. **(b)**

M05 – Spindle stop/off

G90 – Absolute coordinate system

G00 – Point to point positioning

G02 – Clockwise circular interpolation

45. **(a)**

List-I denotes the unconventional machining process and List-II denotes the mechanism of material removal.

- Abrasive jet machining – Brittle fracture
- Laser beam machining – Melting vaporization
- Electrochemical machining – Chemical dissolution
- Electro discharge machining – Melting and cavitation

46. **173.5 (171 to 175)**

$$\varepsilon_T = \ln\frac{L}{L_0} = \ln\left(\frac{50}{100}\right) = -\ln(2) = -0.693$$

$$|\varepsilon_T| = 0.693$$

$$\text{Flow stress, } \sigma_0 = \sigma_f = 200\,(0.02 + 0.693)^{0.42}$$

$$= 173.511 \text{ MPa}$$

47. **(1361.34) (1360 to 1363)**

$$\text{MRR} = \frac{AI}{\rho ZF}$$

$$\frac{3}{60} = \frac{56 \times I}{7.9 \times 2 \times 96500}$$

$$I = 1361.34 \text{ Amp}$$

48. **(1.1256) (1.10 to 1.20)**

$$\underset{100\text{ kPa}}{(1)} \xrightarrow{\text{Compression}} \underset{500\text{ kPa}}{(2)} \xrightarrow{\text{Cooling}} \underset{35°\text{C } 500\text{ kPa},\ \phi_3 = 1}{(3)}$$

At condition (3),

$$P_{VS3} = P_{V3} \qquad (\because \phi = 1)$$

$$P_{V3} = 5.628 \text{ kPa}$$

In process (2) to (3) there is no condensation,

So, $P_{V2} = P_{V3}$

$$= 5.628 \text{ kPa}$$

In process (1) to (2)

$$P_{t2} = 5P_{t1}$$

Similarly, $P_{V2} = 5P_{V1}$

$$P_{V1} = \frac{5.628}{5} = 1.1256 \text{ kPa}$$

49. **(a, c)**

VARS systems using water-LiBr pair are extensively used in large capacity air conditioning. It is used only in applications requiring refrigeration at temperatures above 0°C, since water is used as refrigerant.

50. **(a, b, c)**

Because no melting occurs, friction welding is not actually a welding process in the traditional sense, but a forging technique.

■■■■

