GATE 2016 – A Brief Analysis

(Based on student test experiences in the stream of ME on 31st January, 2016 – (Forenoon Session)

Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total No of Questions
Engineering Mathematics	5	4	9
Engineering Mechanics	1	4	5
Strength of Materials	2	3	5
Design of Machine Elements	1	1	2
Theory of Machines	2	1	3
Vibrations	1	1	2
Fluid Mechanics	3	3	6
Thermal Science	1	4	5
Heat Transfer	3	3	6
Manufacturing Science	4	4	8
Industrial Engineering	2	2	4
Verbal Ability	3	2	5
Numerical Ability	2	3	5
	30	35	65

Type of questions asked from each section

Engineering Mechanics	Questions came from Free body diagrams.
Strength of materials	Questions came from 2D stress, Bending equation
Machine design	Questions came from Bearings.
Theory of machines	Questions came from Degrees of freedom for links, Balancing.
Vibrations	Questions came from Resonance, single degree of freedom of free vibration.
Fluid mechanics and Hydraulic machines	Questions came from Stream lines, Boundary layer, Impact of jet, Branched piper.
Thermal science	Questions came from Air compressors, vapour compression refrigeration system, SFEE, Psychrometry.
Heat transfer	Questions came from composite slabs, Lumped system analysis, Dimensions less numbers, Radiation, Heat exchanger.
Manufacturing	Questions came from Machining, Casting, Punching, welding and Material science.
Industrial Engineering	Questions came from NC codes, PERT, LPP, Forecasting.

Questions from the Paper
General Aptitude

1. S, P, M and E are four persons, working on project efficiency of M is twice that of others and M works only for half of the total days worked by E. M works 6 hours/day and E works 12 hours/day. Ratio of contribution of work to project of M and E is (i.e., work done by M/work done by E)

(A) 1 : 1 (B) 1 : 2 (C) 1 : 4 (D) 1 : 3

Key: (A)

Exp: M - $6\text{hr/day} - 1$ unit of work

$E - 12\text{h/day} - 1$ unit of work

$$\frac{M}{E} = \frac{1}{1}$$

2. Mr. X has height 6 feet and Mr. Y has 4 feet. Identify the correct statement

(A) Mr. X is longer than Mr. Y
(B) Mr. X is taller than Mr. Y
(C) Mr. X is bigger than Mr. Y
(D) Mr. X is higher than Mr. Y

Key: (B)

3. The teacher was _____ on teacher's day for her work.

(A) Facilitated (B) Felicitated (C) Fascinated (D) Facillitated

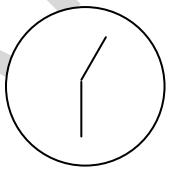
Key: (B)

4. Two hours and 15 min back, reflection of wall clock is viewed in the mirror which shows 1:30. The actual present time in the clock is

(A) 8:15 (B) 11:45 (C) 12:15 (D) 12:45

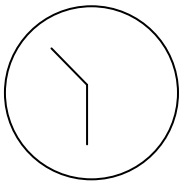
Key: (D)

Exp: If reflection is seen as



1:30

Actual will be



10:30

Thus present time will be $10:30 + 2:15 = 12:45$

5. A wire of length 340 mm is cut into two pieces. One piece in used to form a square and other piece is used to form a rectangle whose sides are in the ratio of 1: 2. Determine the side of square if combined area of square and rectangular is minimum (in mm)

(A) 30 (B) 40 (C) 180 (D) 160

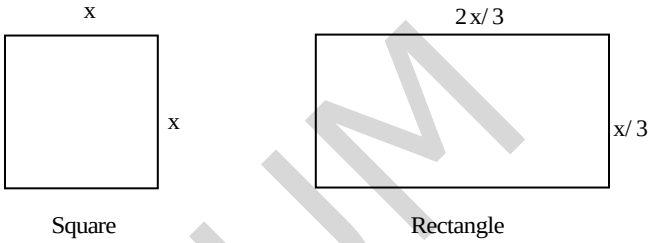
Exp: $x + y = 340$

$$\text{Perimeter of rectangle} = 2\left[\frac{x}{3} + \frac{2x}{3}\right] = 2x$$

$$\text{Perimeter of square} = 340 - 2x$$

$$\text{Length of square} = \frac{340 - 2x}{4}$$

$$\text{Total area} = \left(\frac{340 - 2x}{4}\right)^2 + \frac{2}{9}x^2 = f(x)$$



$$f'(x) = \frac{4}{9}x - \frac{2x - 340}{4} = 0$$

$$\Rightarrow \frac{4}{9}x = \frac{1}{4}(340 - 2x) \Rightarrow x = 90$$

$$\text{Length of square} = \frac{340 - 2x}{4} = 40\,\text{mm}$$

Technical

1. A cylindrical steel rod of 0.01m in diameter and 0.2m in length is first heated to 750°C and then immersed in a water bath at 100°C. The convective heat transfer coefficient is $250\ W/m^2\ K$. The density specific heat and thermal conductivity are $7801\,kg/m^3, 473$ J/kg K and $43\,W/mK$ respectively. The time required for the rod to reach 300°C is _____ seconds

Key: 43.49

Exp: d = 0.01 m

L = 0.2m, R=7801 kg/m^3.

$t_i = 750^\circ C, C = 473 J/kgK$

$t_\infty = 100^\circ C,\ k = 43\,W/mK$

$$h = 250\,W/m^2\,K, L_c = \frac{V}{A} = \frac{\frac{\pi}{4}d^2\ell}{\pi d\ell} = \frac{d}{4}$$

$$\ln\left(\frac{t - t_\infty}{t_i - t_\infty}\right) = \frac{-hA}{\rho Vc} \times \tau = \frac{-h}{\rho c L_c} \times \tau$$

$$\ln\left(\frac{t - t_\infty}{t_i - t_\infty}\right) = \frac{-h \times 4}{\rho c \times d} \times \tau$$

$$\ln\left(\frac{300 - 100}{750 - 100}\right) = \frac{-250 \times 4}{7801 \times 473 \times 0.01} \times \tau$$

$$\tau = 43.49s$$

2. Internal gears are manufactured by
(A) Hobbing
(B) Shaping with pinion cutter
(C) Shaping with rack cutter
(D) Milling

Key: (A)

3. Grashoff number signifies the ratio of
(A) inertia force to viscous force
(B) buoyancy force to viscous force
(C) buoyancy force to inertia force
(D) Inertial force to surface tension force

Key: (B)

Exp: Grashoff number $(Gr) = \dfrac{\text{Inertia force} \times \text{Buoyant force}}{(\text{Viscous force})^2}$

4. Engineering strain of a mild steel sample is recorded has 0.100%, the true strain is
(A) 0.010 %
(B) 0.055%
(C) 0.099%
(D) 0.101%

Key: **(**C)

Exp: $\varepsilon = \dfrac{0.1}{100}$

We know,

$\varepsilon_T = \ln(1+\varepsilon)$, where ε_T is True strain and ε is Engineering strain

$\Rightarrow \varepsilon_T = \ln\left(1+\dfrac{0.1}{100}\right) = 0.0009995 \qquad \therefore \varepsilon_T\% = 0.0009995 \times 100 = 0.099\%$

5. Which of the bearings given below should not be subjected to a thrust load?
(A) Deep groove ball bearing
(B) Angular contact ball bearing
(C) Cylindrical roller bearing
(D) Single row tapered roller bearing

Key: (C)

6. A sheet metal of 2 mm thickness, a hole of 10 mm diameter needs to be punched. Yield strength in tension of the sheet material is 100 MPa and its ultimate shear strength is 80 MPa. The force required to punch the hole (in kN) is _____

Key: 5.0265

Exp:

$t = 2\text{mm}$

$d = 10\text{mm}$

$\tau_s = 80\text{MPa}$

$S_{yt} = 100\text{MPa}$

$F = \pi dt \times \tau_s = \pi \times 10 \times 2 \times 80 = 5026.5\text{N} = 5.0265\text{kN}$

7. In a 3-stage air compressor, the initial pressure is P_1, discharge pressure is and the intermediate pressure are P_2 and P_3 $(P_2 < P_3)$. The total pressure ratio is 10 and the pressure ratios of stages where equal. If $P_1 = 100\,\text{kPa}$, the value of P_3 (in kPa) is _____

Key: 464.16

Exp: 3 stage compressor;

P_1= 100 kPa.

Pressure ratios of all stages are equal

$$\frac{P_2}{P_1} = \frac{P_3}{P_2} = \frac{P_4}{P_3}$$

Overall pressure ratio $= \frac{P_4}{P_1} = 10$

$$\therefore r_p = \frac{P_2}{P_1} = \frac{P_3}{P_2} = \frac{P_4}{P_3} = \sqrt[3]{10} = 2.154$$

$$P_3 = (r_p)^2 \times P_1$$

$$\therefore P_3 = 2.514 \times 2.514 \times 100 = 464.16\,\text{kPa}$$

8. In a single point turning operation with cemented carbide tool and steel work piece, it is found that the Taylors' exponent is 0.25. If the cutting speed is reduced by 50% then the tool life changes by ___ times

Key: 16

Exp: n = 0.25

$$V_2 = V_1/2$$

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

$$V_1 T_1^n = \frac{V_1}{2} T_2^n$$

$$\left(T_2/T_1\right)^{0.25} = 2$$

$$T_2 = T_1 \times 2^4$$

$$T_2 = 16 \times T_1$$

Tool life changes by 16 times

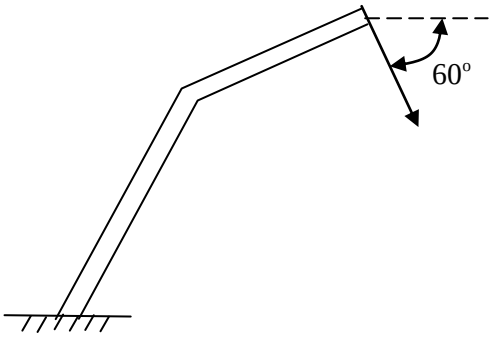
9. In PERT chart, the activity time distribution is

(A) Normal (B) Binomial

(C) Poisson (D) Beta

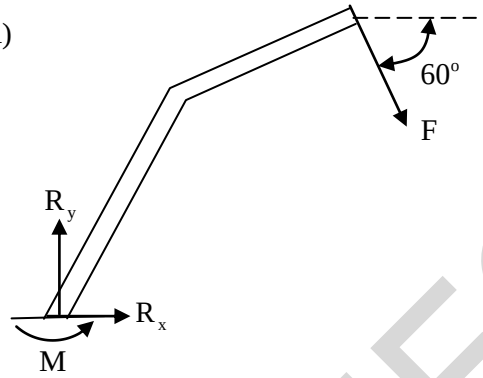
Key: (D)

10. A force F is acting on a bent bar which is clamped at one end as shown in figure.

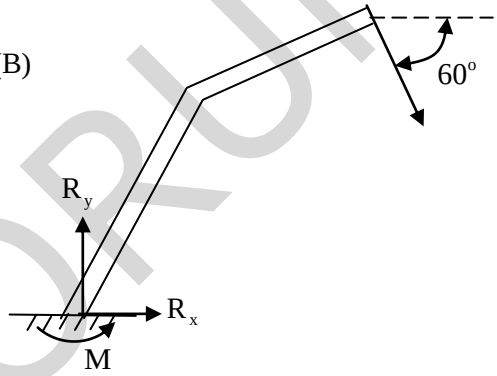


The correct Free body diagram is

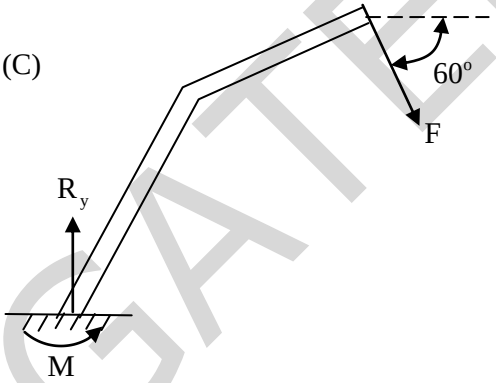
(A)



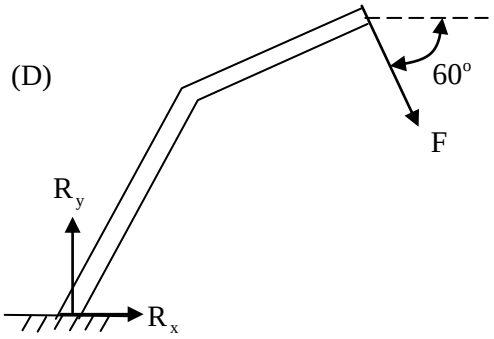
(B)



(C)



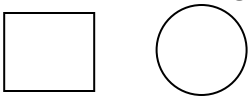
(D)



Key: **(**A)

Exp: A free body diagram is the diagram in which all connecting pieces are removed.
Correct option is (A) because the fixed support will give reaction of forces in x and y direction and moment also.

10. The cross-section of solid bar, made up of same material as shown in the figure, the square cross-section has flexural (bending) rigidity I_1, while the circular cross-section has flexural rigidity I_2, both section have the same cross-section the ratio of $\frac{I_1}{I_2}$ is



(A) $\frac{1}{\pi}$ (B) $\frac{2}{\pi}$ (C) $\frac{\pi}{3}$ (D) $\frac{\pi}{6}$

Key: (C)

Exp: Flexural rigidity = EI

Both have same cross-section area

$\Rightarrow a^2 = \frac{\pi}{4} d^2$ where a is side of square and d is diameter of circle.

$\Rightarrow a^4 = \frac{\pi^2}{16} d^4$

$$\Rightarrow \frac{I_1}{I_2} = \frac{E_1 \times \frac{a^4}{12}}{E_2 \times \frac{\pi d^4}{64}} = \frac{\frac{\pi^2 d^4}{12 \times 16}}{\frac{\pi}{64} d^4} = \frac{\pi}{3} \qquad (E_1 = E_2 \text{ because of same material})$$

11. Match the following part programming code with the respective functions

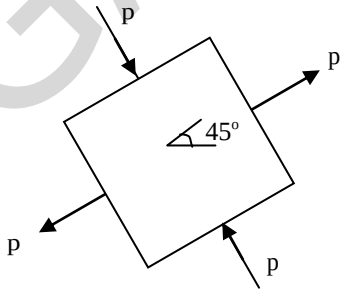
PPC	Function
P. G01	I. Spindle stop
Q. G03	II. Spindle rotation clockwise
R. M03	III. Circular interpolation anticlockwise
S. M05	IV. Linear interpolation

(A) P-II, Q-I, R-IV, S-III (B) $P-IV, Q-II, R-III, S-I$

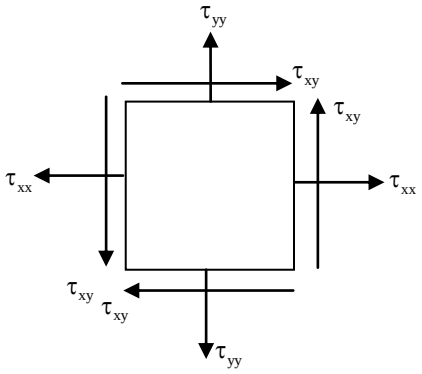
(C) P-IV, Q-III, R-II, S-I (D) P-III, Q-IV, R-II, S-I

Key: (C)

12. The state of stress at a point on an element is shown figure (a). The same of stress is shown in another coordinate system in figure (b).



(a)



(b)

The component of $(\tau_{xx}, \tau_{yy}, \tau_{xy})$ is

(A) $\left(\frac{P}{\sqrt{2}}, \frac{-P}{\sqrt{2}}, 0\right)$ (B) $(0,0,P)$ (C) $\left(P, -P, \frac{P}{\sqrt{2}}\right)$ (D) $\left(0,0,\frac{P}{\sqrt{2}}\right)$

Key: (B)

Exp: We know,

$$\sigma_\theta = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

Where, θ is the location of any oblique plane which making an angle θ in CCW direction.

$\therefore$ When $\theta = -45^o$, $\sigma_\theta = \tau_{xx}$, $\sigma_x = p$, $\sigma_y = -p$

$$\sigma_\theta = \tau_{xx} = \left(\frac{p-p}{2}\right) + \left(\frac{p+p}{2}\right)\cos 90 = 0$$

When $\theta = 45^O$, $\sigma_\theta = \tau_{yy}$

$$\sigma_\theta = \left(\frac{p-p}{2}\right) + \left(\frac{p+p}{2}\right)\cos 90 = 0$$

When $\theta = 45^O$, $\tau_\theta = \tau_{xy}$

We know $\tau_\theta = \left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta - \tau_{xy}\cos 2\theta$

$$\therefore \tau_\theta = \tau_{xy} = \left(\frac{p+p}{2}\right)\sin 90 = p \quad \therefore \tau_{xx}, \tau_{yy}, \tau_{xy} \text{ is } 0, 0, p$$

14. The number of degree of freedom in a planar mechanism having n links and j simple hinge joints is

(A) $3(n-3)-2j$ (B) $3(n-1)-2j$ (C) $3n-2j$ (D) $2j-3n+4$

Key: (B)

15. In wire-cut EDM process, the necessary condition that have to met for making successfully cut are that

(A) Wire and sample are electrically non-conducting
(B) Wire and sample are electrically conducting
(C) Wire is electrically conducting and sample is electrically non-conducting
(D) Sample is electrically conducting and wire is electrically non-conducting

Key: (D)

16. The static defect of a spring gravity, when a mass of 1 kg is suspended from it is 1 mm. Assume the acceleration due to gravity, g = 10 m/s^2. The natural frequency of this spring mass system (in rad/s) is _____

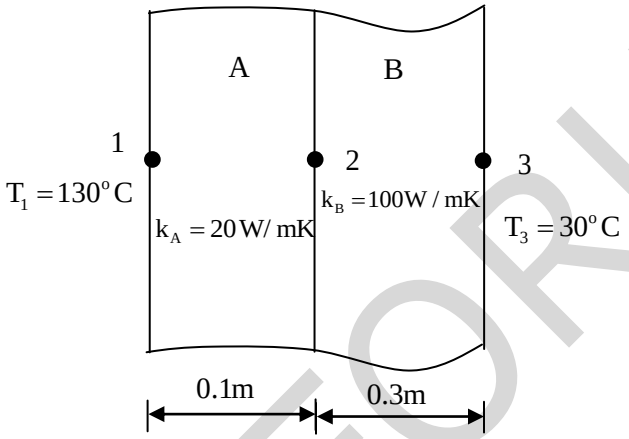
Key: 100

Exp: $\delta = 1\text{mm}$

$g = 10\,\text{m/s}^2$

$\omega_n = \sqrt{\dfrac{g}{\delta}} = \sqrt{\dfrac{10}{10^{-3}}} = \sqrt{10\times10^3} = 100\,\text{rad/s}$

17. Steady 1-D heat conduction takes place across the faces 1 and 3 of a composite slab consisting of slabs A and B in perfect contact as shown in the figure, where k_A, k_B denote the respective thermal conductivites. Using the data as given in the figure, the interference temperature $T_2\left(\text{in}^\circ\text{C}\right)$ is ____.



Key: 67.5

Exp: $\dfrac{T_1 - T_2}{\dfrac{L_A}{k_A \times A}} = \dfrac{T_2 - T_3}{\dfrac{L_B}{k_B \times A}}$

$\dfrac{130 - T_2}{\dfrac{0.1}{20}} = \dfrac{T_2 - 30}{\dfrac{0.3}{100}}$

$390 - 3T_2 = 5T_2 - 150$

$8T_2 = 540$

$T_2 = 67.5^\circ C$

$\therefore$ Interface temperature $= 67.5^\circ C$

18. For a heat exchanger ΔT_{max} is the max temperature difference and ΔT_{min} is the minimum temperature difference between the two fluids LMTD is the log mean and maximum heat and C_{max} are the possible heat transfer (Q_{max}) between the two fluids is

(A) C_{min} LMTD (B) $C_{min}\ \Delta T_{max}$

(C) $C_{max}\ \Delta T_{max}$ (D) $C_{max}\Delta T_{min}$

Key: (B)

Exp: In a heat exchanger, maximum possible heat transfer will be.

$Q_{max} = C_{min}\Delta T_{max}$

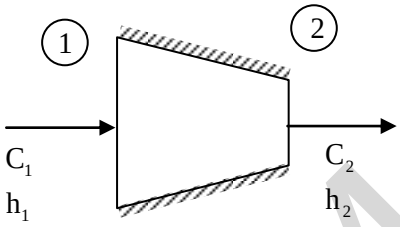
19. Steam at an initial enthalpy of 100 kJ/kg, and inlet velocity of 100 m/s, enters an insulated horizontal nozzle. It leaves the nozzle at 200 m/s. The exit enthalpy (in kJ/kg) is _____

Key: 85

Exp: $h_1 = 100 kJ/kg$

$C_1 = 100 m/s$

$C_2 = 200 m/s$



$$h_1 + \frac{C_1^2}{2000} = h_2 + \frac{C_2^2}{2000}$$

$$h_2 = 100 + \frac{100^2}{2000} - \frac{200^2}{2000} = 85 kJ/kg$$

20. Spot welding of two steel sheets inch 2 mm thick is carried out successfully by passing 4kA of current 0.2 seconds through the electrodes. The resulting weld nugget formed between the sheets is 5 mm in diameter. Assuming cylindrical shape for the nugget, the thickness of nugget is ___mm.

Let end heat of fusion for steel

Effective resistance of weld joint density of steel

Latent Heat of fusion for steel	1400 kJ/kg
Effective resistance of weld joint	$200 \mu\Omega$
Density of steel	8000 kg/m^3

Key: 2.91

Exp: $t_s = 2mm$

$I = 4kA$

$t = 0.2$

$d = 5mm$

$t_n = ?$

$L.H = 1400$

$R = 200 \mu\Omega$

$\rho = 8000 kg/m^3$

Energy supplied = I^2Rt … (a)

$$= \left(4 \times 10^3\right)^2 \times 200 \times 10^{-6} \times 0.2 = 640 J$$

Energy required for melting = $\rho \times V \times (L.H)$ … (b)

$$= 1400 \times 10^3 \times 8000 \times \frac{\pi}{4} \times 5^2 \times 10^{-6} \times t_n = 219911.4858 t_n$$

Equating (a) & (b)

$640 = 219911.4858 t_n \quad t_n = 2.91mm$

21. In a mixture of dry air and water vapour at a total pressure of 750 mm of Hg, the partial pressure water vapour is 20 mm of Hg. The humidity ratio of air (in grams) of water vapour per kg of dry air $\left(\frac{g_{w.v}}{kg\,d.a}\right)$ is_____

Key: 17

Exp: $P_t = 750\ mm\ of\ Hg$

$P_v = 20\ mm\ of\ Hg$

Humidity ratio (or) specific Humidity

$$w = 0.622\frac{P_V}{P_t - P_V}$$

$$= 0.622 \times \left(\frac{20}{750-20}\right)$$

$$= 0.017\ {kg_{w.v}}/{kg\ d.a}$$

$$= 17\ {g_{w.v}}/{kg\ d.a}$$

22. Two parallel plates are separated by a distance of 10 mm and temperature of one plate is 1000 K and that of other is 400 K. If $\varepsilon_1 = 0.5, \varepsilon_2 = 0.25$, the net radiation heat exchange between the plate is kW/m^2 is _____

Key: 11.049

Exp: $$Q_{1-2} = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

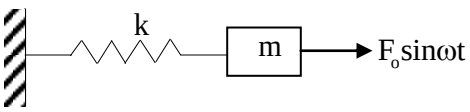
$$= \frac{5.67 \times 10^{-8}\left(1000^4 - 400^4\right)}{\frac{1}{0.5} + \frac{1}{0.25} - 1}$$

$$= 11049.696\ {W}/{m^2} = 11.049\ {kW}/{m^2}$$

$T_1 = 1000K$ | $T_2 = 400K$

$\varepsilon_1 = 0.5$ | $\varepsilon_2 = 0.25$

23. In a single Degree of Freedom, excluded with a frequency of $\sqrt{\frac{3k}{m}}$. What is the ratio of amplitude of excitation to the static deflection because of the forced excitation ____



Key: 0.5

Exp: $$M.F = \pm\frac{1}{1-\left({\omega}/{\omega_n}\right)^2} = \pm\frac{1}{1-3} = \frac{1}{2} = 0.5$$

24. In an exponential smoothing forecast, if the demand for the month of April is 900 units and for the month of May it is 1030 units, with smoothing constant of 0.6. The forecast for the month of June is _____

(A) 850 (B) 927 (C) 910 (D) 970

Key: (D)

Exp:

	Demand	Forecast
April	900	850
May	1030	

$$F_{May} = F_{Apr} + \alpha\left[D_{Apr} - F_{Apr}\right] = 850 + 0.6 \times 50 = 880$$

$$F_{June} = F_{May} + \alpha\left[D_{May} - F_{May}\right] = 880 + 0.6\left[1030 - 880\right] = 970$$

25. In a normal distribution curve, the percentage area between +3 and -3 standard deviation value is _____

Key: 99.74

Exp: