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ESE 2022 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 16

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials [All Topics]

Section B : Systems & Signal Processing + Communication Systems [All Topics]

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2 [Part Syllabus]

1.	(b)	**16.**	(d)	**31.**	(d)	**46.**	(b)	**61.**	(b)
2.	(c)	**17.**	(a)	**32.**	(d)	**47.**	(d)	**62.**	(c)
3.	(b)	**18.**	(b)	**33.**	(a)	**48.**	(c)	**63.**	(c)
4.	(b)	**19.**	(d)	**34.**	(d)	**49.**	(c)	**64.**	(c)
5.	(b)	**20.**	(c)	**35.**	(c)	**50.**	(c)	**65.**	(b)
6.	(c)	**21.**	(c)	**36.**	(b)	**51.**	(a)	**66.**	(b)
7.	(c)	**22.**	(d)	**37.**	(b)	**52.**	(a)	**67.**	(d)
8.	(a)	**23.**	(b)	**38.**	(c)	**53.**	(d)	**68.**	(a)
9.	(b)	**24.**	(d)	**39.**	(d)	**54.**	(b)	**69.**	(c)
10.	(a)	**25.**	(c)	**40.**	(b)	**55.**	(a)	**70.**	(c)
11.	(c)	**26.**	(b)	**41.**	(d)	**56.**	(d)	**71.**	(d)
12.	(b)	**27.**	(c)	**42.**	(d)	**57.**	(c)	**72.**	(a)
13.	(b)	**28.**	(d)	**43.**	(c)	**58.**	(a)	**73.**	(c)
14.	(b)	**29.**	(a)	**44.**	(a)	**59.**	(a)	**74.**	(b)
15.	(d)	**30.**	(b)	**45.**	(a)	**60.**	(a)	**75.**	(a)

DETAILED EXPLANATIONS

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials

1. (b)

Cross product has the following basic properties:

- It is anticommutative

$$A \times B = -B \times A$$

- It is not associative

$$A \times (B \times C) \neq (A \times B) \times C$$

- It is distributive

$$A \times (B + C) = (A \times B) + A \times C$$

2. (c)

- The polarity of charges may be positive or negative like charges repel, while unlike charges attract.
- Columb's law states that the force F between two point charges Q_1 and Q_2 is
  - Along the line joining them
  - Directly proportional to the product Q_1Q_2 of the charges.
  - Inversely proportional to the square of the distance R between them

$$F = \frac{kQ_1Q_2}{R^2}$$

3. (b)

$$I = \iint \vec{J} \cdot \vec{ds}, \text{ where } ds = r^2 \sin\theta \, d\phi \, d\theta \, \hat{a}_r$$

$$I = \int_{\theta=0}^{\frac{\pi}{2}} \int_{\phi=0}^{2\pi} \frac{1}{r^3} 2\cos\theta \, r^2 \sin\theta \, d\phi \, d\theta \Big|_{r=0.1}$$

$$= \frac{2}{r} 2\pi \int_{\theta=0}^{\frac{\pi}{2}} \sin\theta \, d(\sin\theta)\Big|_{r=0.1}$$

$$= \frac{2}{r} \times 2\pi \int_{\theta=0}^{\frac{\pi}{2}} \sin\theta \, d(\sin\theta)\Big|_{r=0.1}$$

$$= \frac{4\pi}{0.1} \frac{\sin^2\theta}{2}\Big|_0^{\pi/2} = 20\pi = 62.8 \text{ A}$$

4. (b)

A dielectric material is linear if $D = \varepsilon E$ holds that is, if ε is independent of E. It is homogeneous if ε is independent of position. It is isotropic if ε is a scalar.

5. (b)

The capacitor in figure can be treated as consisting of two capacitors C_1 and C_2 in series

$$C_1 = \frac{\varepsilon_0 \varepsilon_{r1} A}{\frac{d}{2}} = \frac{2\varepsilon_0 \varepsilon_{r1} A}{d}$$

$$C_2 = \frac{2\varepsilon_0 \varepsilon_{r2} A}{d}$$

The total capacitance C is given by

$$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{2\varepsilon_0 A}{d} \frac{(\varepsilon_{r1}\varepsilon_{r2})}{\varepsilon_{r1} + \varepsilon_{r2}}$$

$$C = \frac{2 \times 10^{-9}}{36\pi} \times \frac{30 \times 10^{-4}}{5 \times 10^{-3}} \times \frac{4 \times 6}{10} = 25.46 \text{ pF}$$

6. (c)

$$H = -\nabla V_m$$

$$= -\left(\frac{\partial}{\partial x}\hat{a}_x + \frac{\partial}{\partial y}\hat{a}_y + \frac{\partial}{\partial z}\hat{a}_z\right)(x^2 y + y^2 x + z)$$

$$= -(2xy + y^2)\hat{a}_x - (x^2 + 2xy)\hat{a}_y - \hat{a}_z$$

$$H(1, 1, 1) = -3\hat{a}_x - 3\hat{a}_y - \hat{a}_z$$

$$B = \mu_o \mu_r H$$

$$= 4\pi \times 10^{-7} \times 1 \times \sqrt{3^2 + 3^2 + 1^2} = 5.5 \mu T$$

8. (a)

From electrical point of view, materials can be classified as conductors ($\sigma >> 1, \varepsilon_r = 1$), dielectrics ($\sigma << 1, \varepsilon_r \geq 1$).

9. (b)

$$\nabla \cdot \vec{D} = \rho_v$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

10. (a)

For $\vec{V}$ to be irrotational,

$$\nabla \times \vec{V} = 0$$

$$\nabla \times V = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ (x+2y+az) & (bx-3y-z) & (4x+cy+2z) \end{vmatrix}$$

$$= \hat{a}_x(c+1) - \hat{a}_y(4-a) + \hat{a}_z(b-2) = 0$$

Therefore, $c = -1;$

$4 - a = 0;$

$a = 4$

and, $b - 2 = 0;$

$b = 2$

11. (c)

Induced emf in the conductor

$$V = v \times B$$

$$|V| = 2 \times 100 = 200 \text{ V}$$

12. (b)

$$\vec{B} = \nabla \times \vec{A} = -\frac{\partial A_z}{\partial \rho}\hat{a}_\phi = \frac{\rho}{2}\hat{a}_\phi,\ ds = d\rho\, dz\, \hat{a}_\phi$$

Hence, $$\psi = \int_s \vec{B}\cdot\vec{ds} = \frac{1}{2}\int_0^5\int_1^2 \rho\, d\rho\, dz = \frac{1}{4}\rho^2\Big|_1^2 (5) = \frac{1}{4}\times 3\times 5 = 3.75 \text{ Wb}$$

13. (b)

Convection current does not obey Ohm's law.

14. (b)

The polarisation is given as

$$\vec{P} = \chi_e \varepsilon_0 \vec{E} = (\varepsilon_r - 1)\varepsilon_0 \vec{E}$$

$$= (\varepsilon_r - 1)\varepsilon_0 \frac{\vec{D}}{\varepsilon_0 \varepsilon_r} \ldots\ldots \{\because\ \varepsilon_r = 1 + \chi_e\}$$

$$= \left(1 - \frac{1}{\varepsilon_r}\right)\vec{D} = \left(1 - \frac{1}{2.8}\right)\times 3\times 10^{-7}$$

$$= \frac{1.8}{2.8}\times 3\times 10^{-7} = 1.93\times 10^{-7}\,\text{C/m}$$

15. **(d)**

All given statements are correct.

16. **(d)**

As i is incremented first before print for each loop.

Hence output will be 1 2 3 4 5 6 7.

17. **(a)**

$$\text{RAM memory size} = 256 \times 4 \text{ RAM} = 2^8 \times 4$$

Memory chip requires 8 address lines and 4 data lines.

$$\text{Required memory capacity} = 4096 \text{ bytes} = 4096 \times 8 \text{ bits}$$

$$\text{Address line needed} = 12 \; (\because \; 2^{12} = 4096)$$

$$\text{Data line needed} = 8$$

$$\therefore \quad \text{Number of row required} = \frac{4096}{256} = 16$$

$$\text{Number of columns required} = \frac{8}{4} = 2$$

Total number of RAMs each of size 256 × 4 required = 16 × 2 = 32

18. **(b)**

CISC (Complex Instruction Set Computer) has single register set.

19. **(d)**

All given statements are correct regarding fully associative cache.

20. **(c)**

Virtual memory provides higher CPU utilization and throughput.

21. **(c)**

$$\text{Virtual address} = 64 \text{ bits}$$

$$\text{Page size} = 4 \text{ KB} = 2^{12} \text{ B}$$

128 page table with 4 way associative.

$$\text{So,} \quad \frac{2^7}{2^2} = 5 \text{ bits for set}$$

$$\therefore \quad \text{Total bits for TAG} = 64 - (12 + 5) = 47 \text{ bits}$$

22. **(d)**

Multi-threading is faster compared to multi-tasking.

23. **(b)**

- OSI model follows horizontal approach.
- OSI model has separate presentation layer. The number of layer is seven.

24. (d)

Capacity of disk = Number of surfaces × Number of tracks per surface × Number of sector per track × Data

$= 16 \times 128 \times 256 \times 512$ B

$= 2^4 \times 2^7 \times 2^8 \times 2^9$ B

$= 2^{28}$ bytes $= 2^8$ Mbytes where $[1M = 2^{20}]$

25. (c)

There is not limit in calling C functions to make use of same functionality whenever needed.

26. (b)

Range of 2's complement representation: -2^{n-1} to $2^{n-1} - 1$

Lower range for 64 bit word size = -2^{63}

Upper range of 64 bit word size = $2^{63} - 1$

27. (c)

Cache size = 64 kilobytes = 64×2^{10} bytes

Block size = 4 bytes

$$\text{Number of lines} = \frac{64 \times 2^{10}}{4} = 2^{14}$$

28. (d)

All given statements are correct regarding computer organisation.

29. (a)

Contiguous allocation of a file is defined by the disk address of the first block and length (in block units).

30. (b)

Processor is suspended twice for single bus detached DMA.

31. (d)

For face centered cubic unit cell:

- Number of atoms per unit cell = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 1 + 3 = 4$
- The coordination number for FCC unit cell is 12.
- Atomic packing fraction (APF) = $\dfrac{4 \times \frac{4}{3}\pi r^3}{a^3}$

As, $r = \dfrac{a\sqrt{2}}{4}$

$$\text{APF} = \frac{4 \times \frac{4}{3}\pi\left(\frac{\sqrt{2}}{4}\right)^3 a^3}{a^3} = 0.74$$

32. (d)

All given statements are correct.

33. (a)

Electronic polarization is independent of temperature.

34. (d)

Given lattice constant a : 8 Å

Distance between the two atoms is equivalent to nearest neighbour distance

For diamond structure

$$\text{Nearest neighbour distance} = \frac{\sqrt{3}}{4}a$$

$$\text{Distance between two atoms} = \frac{\sqrt{3}}{4} \times 8 = 2\sqrt{3}\,\text{Å} = 3.46\,\text{Å}$$

35. (c)

As the number of bonding electron increases, the bond energies and melting point also increases in metallic solids.

36. (b)

Given, $\mu = 0.12\ \text{N/A}^2$

Relative permeability, $\mu_r = \frac{\mu}{\mu_0} = \frac{0.12}{4\pi \times 10^{-7}} = 95492.96$

Magnetic susceptibility, $\chi_m = \mu_r - 1 = 95491.96$

37. (b)

Diamagnetic specimen sets itself perpendicular to the applied magnetic field.

38. (c)

Given, $H_o = 4 \times 10^5\ \text{A/m}$

$H_c = 1 \times 10^5\ \text{A/m}$

$T = 8\ \text{K}$

Using relation, $H_c = H_o\left[1 - \left(\frac{T}{T_c}\right)^2\right]$

$$1 \times 10^5 = 4 \times 10^5\left[1 - \left(\frac{8}{T_c}\right)^2\right]$$

$$\frac{1}{4} = 1-\left(\frac{8}{T_c}\right)^2$$

$$\left(\frac{8}{T_c}\right)^2 = 1-\frac{1}{4}$$

$$\frac{8}{T_c} = \sqrt{\frac{3}{4}} \text{ or } T_c = \frac{16}{\sqrt{3}} = 9.24\,T$$

39. (d)

All given statements are correct for superconductors.

40. (b)

Resistance, $R = \rho\frac{l}{A}$

Resistivity, $\rho = \frac{RA}{l} = \frac{0.24\times0.4\times10^{-6}}{2\text{ m}}$

$\rho = 0.048 \times 10^{-6}$ or 4.8×10^{-8} ohm-m

41. (d)

The conductivity is given by

$$\sigma = n_i e\,(\mu_e + \mu_h)$$

$$n_i = \frac{\sigma}{e(\mu_e+\mu_h)} = \frac{1}{\rho e(\mu_e+\mu_h)}$$

$$= \frac{1}{3.16\times10^3\times1.6\times10^{-19}(0.14+0.06)}$$

$$= \frac{1}{1.011\times10^{-16}} = 9.89\times10^{15}/\text{m}^3$$

42. (d)

All given statements regarding ionic non-polar solids are correct.

43. (c)

Moisture increases dissipation and dielectric constant of insulating materials.

44. (a)

Ideal insulating liquid has low dielectric dissipation factor.

45. (a)

Both statements are correct. Because if centre of gravity of positive charge coincides with the centre of gravity of negative charge, the electric dipole for each molecule will be zero in the absence of electric field.

Section B : Systems & Signal Processing + Communication Systems

46. (b)

$$y(t) = \frac{d}{dt}[u(-2-t)+u(t-2)]$$

by differentiating $u(t)$ we get

$$\therefore \quad y(t) = -\delta(-2-t) + \delta(t-2)$$
$$= -\delta(t+2) + \delta(t-2)$$
$$Y(\omega) = -e^{j2\omega} + e^{-j2\omega}$$
$$= -[e^{j2\omega} - e^{-j2\omega}]$$
$$= -2j \sin 2\omega$$

47. (d)

For a Causal system, $h(t) = 0;\ t < 0$.

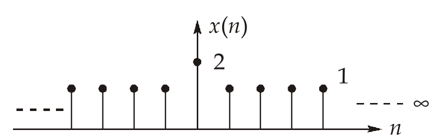
So $h(t)$ is limited in time domain and will have infinite extend in frequency domain.

Option (d) have infinite extend.

48. (c)

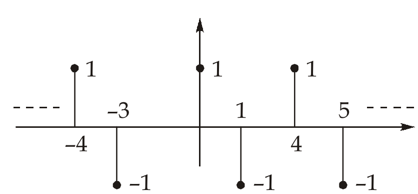
Option (a): $x_1(t)$ exist from 0 to ∞, so it can't be periodic signal.

Option (b):



$x(0) \neq x(1)$ so it not a periodic signal.

Option (c):



So given signal is period with period number = 4 .

Option (d): $x_4(t) = e^{-t} \cdot e^{jt}$

$$= e^{-t}[\cos t + j \sin t]$$
$$\downarrow$$

Since damping is present, magnitude of $[\cos t + j \sin t]$ keep on decreasing with time. So it can't be periodic signal.

Because for a periodic signal.

$$x(t) = x(t \pm nT_0)$$

49. (c)

$$x(n) = \left(\frac{1}{2}\right)^n u(n) + \left(\frac{1}{2}\right)^{-n} u(-n-1)$$

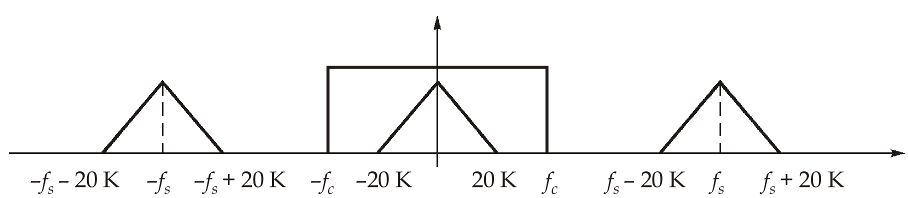
$$= \underbrace{\left(\frac{1}{2}\right)^n u(n)}_{\text{Causal signal}} + \underbrace{2^n u(-n-1)}_{\text{Non-causal signal}}$$

$$\downarrow \qquad\qquad \downarrow$$

$$|z| > \frac{1}{2} \qquad\qquad |z| < 2$$

So, ROC; $\frac{1}{2} < |z| < 2$

50. (c)



$$f_c = 30 \text{ kHz}$$

To reconstruct $m(t)$

$$f_c \le f_s - 20 \text{ K}$$

$$f_{s\,(\text{min})} = f_c + 20 \text{ K}$$

$$= 37 + 20 = 57 \text{ kHz}$$

51. (a)

$$e^{-at}u(t) \xrightarrow{L.T} \frac{1}{s+a};\ \sigma > -a$$

$$-e^{-at}u(-t) \xrightarrow{L.T} \frac{1}{s+a};\ \sigma < -a$$

$$x(t) = e^{-3t}\,u(t) + e^{2t}\,u(-t)$$

$$x(s) = \frac{1}{\underbrace{s+3}_{\sigma > -3}} - \frac{1}{\underbrace{s-2}_{\sigma < 2}}$$

$$= \frac{s-2-s-3}{(s+3)(s-2)} = \frac{-5}{s^2+s-6};\ -3 < \sigma < 2$$

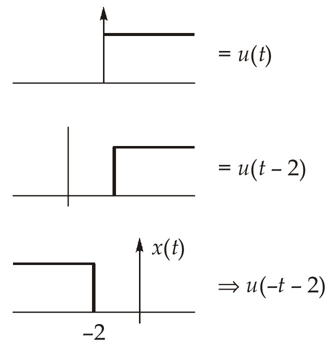
52. (a)

$$h[n] = 3\delta[n-1] + 2\delta[n-2] + \delta[n-3]$$

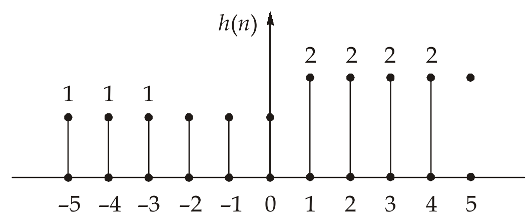
$$H(z) = 3z^{-1} + 2z^{-2} + z^{-3}$$

$$H(1) = 3 \times 1 + 2 \times 1 + 1 = 6$$

53. (d)



54. (b)



Since, $\sum_{n=-\infty}^{\infty} h(n) = 14 < \infty$, so the given system is stable

Since $h(n)$ depends an past present values and future values of inputs so, it is non-causal, it would be causal if $h(n) = 0;\ n < 0$.

55. (a)

$y(n) - 3y(n-1) + 2y(n-2) = x(n)$

On taking z-transform if above expression.

$Y(z) - 3z^{-1}\,Y(z) + 2z^{-2}\,Y(z) = X(z)$

$$\frac{Y(z)}{X(z)} = \frac{1}{1-3z^{-1}+2z^{-2}} = \frac{z^2}{z^2-3z+2}$$

$$\frac{H(z)}{z} = \frac{z}{(z-1)(z-2)} = \frac{-1}{z-1} + \frac{2}{z-2}$$

$$H(z) = \frac{-z}{z-1} + \frac{2z}{z-2}$$

On taking inverse z-transform.

$$h(n) = -u(n) + 2\,(2)^n\,u(n)$$

56. (d)

$$v(t) = 5\cos(10^6\,\pi t) - \frac{5}{2}\cos(10^6\,\pi t - 10^3\,\pi t) + \frac{5}{2}\cos(10^6\,\pi t + 10^3\,\pi t)$$

Since, $\beta < 1$ or $\beta = \frac{1}{2}$

So, it is Narrow Band Frequency Modulated signal.

57. (c)

Filter system and balance modulator are components used to generate SSB-SC whereas Phase-shift method is separate method used to generate SSB-SC signal hence it is not a component.

58. (a)

In asynchronous TDM, number of slots in each frame is less than that of number of signal sources.

59. (a)

$$\text{Quantization noise/error} = \pm\frac{\Delta}{2}$$

$$\Delta = \text{Step size}$$

$$\Delta = \frac{V_H - V_L}{L}\ ;\ L = \text{quantization levels}$$

So, quantization noise depends on step size and step size depends on number of quantization levels.

60. (a)

FIR filters are usually implemented using structure with no feedback. So, FIR filters are non-recursive. If there is no feedback means there will be only zeros.

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2

61. (b)

With negative feedback of 2%

New lower cut off frequency,

$$f_L' = \frac{f_L}{1 + A\beta} = \frac{1000}{(1 + 800 \times 0.02)}$$

$$= \frac{1000}{1 + 16} = 58.82 \text{ Hz}$$

New higher cut off frequency

$$f_H' = 10 \times 10^3 (1 + 800 \times 0.02) = 170 \text{ kHz}$$

$$\text{Ratio} = \frac{f_H'}{f_L'} = \frac{170 \times 10^3}{58.82} = 2890$$

62. (c)

For basic amplifier configuration correct condition for voltage and current amplifier are:

Voltage amplifier: $Z_i = \infty$, $Z_o = 0$

Current amplifier: $Z_i = 0$, $Z_o = \infty$

63. (c)

To produce oscillations the feedback should be positive i.e. feedback voltage should be in phase with input voltage V_i.

64. (c)

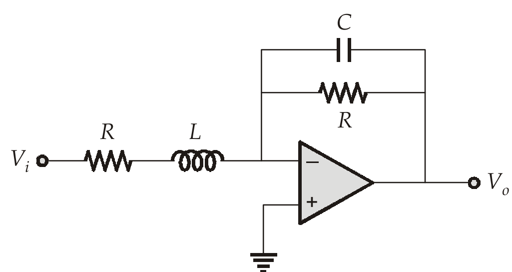
Both given statements are correct regarding low frequency response approximate mode of BJT amplifier.

65. (b)

Frequency of oscillation $f_o = \frac{1}{2\pi\sqrt{6}\,RC}$

$$= \frac{1}{2\times 3.14\times\sqrt{6}\times 20\times 5.28\times 10^{-9}\times 10^{3}} = 615.3 \text{ Hz}$$

66. (b)



$$\frac{V_i - 0}{R + sL} = \frac{V_o - 0}{\dfrac{R}{RCs+1}}$$

$$\frac{V_o}{V_i} = \frac{R}{(R+sL)(RCs+1)}$$

This is a low pass filter, because

At, $\omega = \infty$, $\frac{V_o}{V_{in}} = 0$

$\omega = 0$, $\frac{V_o}{V_{in}} = 1$

67. (d)

555 times can operate in monostable and astable modes.

68. (a)

$$\text{Nominal ratio} = \frac{\text{Rated primary winding voltage}}{\text{Rated secondary winding voltage}} \text{ for a P.T.}$$

69. (c)

0.5 percent of reading = 0.005 × 5 = 0.025 V

The display for 5.00 V read on 10 V scale of $3\frac{1}{2}$ digit meter is 5.00 as there are four digit positions.

The digit in the LSD has a value 0.01 V. $\left[\because \text{resolution} = \frac{1}{10^3}\times 10 = 0.01\,\text{V}\right]$

$\therefore$ Total possible error is 0.025 + 0.01 = 0.035 V

70. **(c)**

Analog data acquisition system are used when wide frequency width is required.

Digital data acquisition systems are used when the physical quantity being monitored has a narrow bandwidth.

71. **(d)**

There is no controlling torque acting upon the moving system, the currents being led into the coils by fine ligaments which exert no control.

72. **(a)**

The natural frequency of vibration of the reeds depends upon their weight and dimensions. Since the reeds have different weights and sizes, their natural frequencies of vibration are different.

73. **(c)**

Magnitude of limiting error = 0.01 × 100 = 1V

$$\%\ \text{error} = \frac{1}{40}\times 100 = 2.5\%$$

74. **(b)**

$$\text{Modulus of elasticity} = \frac{\text{Stress}}{\text{Strain}}$$

Strain, $\in = \frac{\text{Stress}}{\text{Modulus of elasticity}} = \frac{1000}{2\times 10^6} = 5\times 10^{-4}$

Gauge factor, $G = \frac{\frac{\Delta R}{R}}{\in}$

$$\Delta R = \in G\,R$$
$$= 5 \times 10^{-4} \times 3 \times R$$
$$= 15 \times 10^{-4} \times 1000 = 1.5\ \Omega$$

75. **(a)**

The monostable multi-vibrator is also referred as 'mono shot' or univibrator. Since only one triggering signal is required to revert to the original stable state.

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