Branch: Electrical Engineering

Mock-A - Solutions

GATE-2020 General Aptitude (GA)

01. Ans: (A)

Sol: Vulgarity (n.) means offensive speech or conduct.

02. Ans: (A) **03. Ans: (B)**

04. Ans: (A)

Sol: Cylinder volume = $\pi r^2 h$ = $\frac{22}{7} \times 10 \times 10 \times 14 = 4400\ m^3$

05. Ans: (D)

Sol: Speed = 10 kmph = $10\times\frac{5}{18} m/\sec$ = $\frac{50}{18} m/\sec$

Man walks 50 m in 18 sec.

06. Ans: (D)

Sol: Rate downstream = (24/2) kmph = 12 kmph.

Rate upstream = (24/4) kmph = 6 kmph.

Therefore, speed in still water = 1/2* (12 + 6) = 9 kmph.

07. Ans: (B)

Sol: Let principle be 4. Then amount = $4\times\frac{7}{4}=7$

Interest = 7 - 4 = 3

Rate of interest $=\frac{3\times100}{4\times4}=18\frac{3}{4}\%$

08. Ans: (C)

Sol: Net part filled in 1 hour = $\frac{1}{10}+\frac{1}{12}-\frac{1}{20}=\frac{6+5-3}{60}=\frac{11-3}{60}=\frac{8}{60}=\frac{2}{15}$

The tank will be full in $\frac{15}{2}$ hrs

= 7 hrs.30 min.

09. Ans: (A)

Sol: Share of wealth that C gets (in Rs lakhs) = 20

Tax = 40%

$\Rightarrow$ Wealth tax (in Rs lakhs) that C has to pay

$=\frac{40}{100}\times20=8$

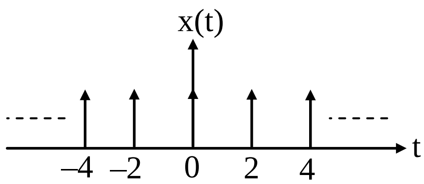
10. Ans: (A)

Sol: Note that an assumption is like a premise in that if it is wrong the argument is invalid, and if it is right it supports the conclusion. If the statement in (A) is correct, it supports the idea that point and shoot is not art, but if it is wrong, and choosing what to point the camera at involves art, then the argument is invalid. Hence, (A) is an assumption.

Specialization (EE)

01. Ans: (D)

Sol: $x(t) = \sum_{n=-\infty}^{\infty} \delta(t-2n)$



Fourier transform of periodic signal x(t) is

$$X(\omega) = 2\pi \sum_{n=-\infty}^{\infty} C_n \, \delta(\omega - n\omega_s)$$

Where $C_n = \frac{1}{T}\int_0^T x(t) e^{-jn\omega_0 t} dt$

$$= \frac{1}{2}\int_0^2 \delta(t) e^{-jn\pi t} dt = \frac{1}{2}$$

$$X(\omega) = \frac{2\pi}{2} \sum_{n=-\infty}^{\infty} \delta(\omega - n\pi)$$

$$X(\omega) = \pi \sum_{n=-\infty}^{\infty} \delta(\omega - n\pi)$$

02. Ans: (D)

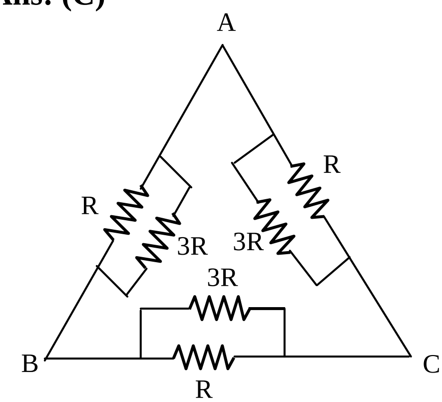
P (x = 1) = 0.5 P (x = 2)

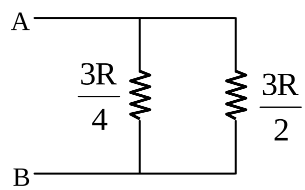
$$\frac{\lambda e^{-\lambda}}{1!} = \frac{1}{2}\frac{\lambda^2 e^{-\lambda}}{2!}$$

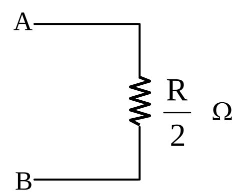
$\Rightarrow \lambda = 4$

$$P(x=4) = \frac{\lambda^4 e^{-\lambda}}{4!} = \frac{4^4 e^{-4}}{24} = \frac{32}{3} e^{-4}$$

03. Ans: (C)







04. Ans: (C)

05. Ans: 2

Sol: Three non touching loops = 2

Three non touch loop gains = $G_1 H_1 G_3 H_3 G_5 H_4$

$= G_1 H_1 G_3 H_3 G_6 H_5$

06. Ans: (D)

Sol: $I_0 = C$

$I_1 = D$

$I_2 = \overline{C}$

$I_3 = \overline{C}\,\overline{D}$

S_1	S_0	
A	**B**	**Y**
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

F(A, B, C, D)

$= \bar{A}\,\bar{B}\,C + \bar{A}\,BD + A\bar{B}\,\bar{C} + AB(\bar{C}\,\bar{D})$

$= \bar{A}\,\bar{B}\,C(D+\bar{D}) + \bar{A}\,B(C+\bar{C})D$

$+ A\bar{B}\,\bar{C}\,(D+\bar{D}) + AB\bar{C}\,\bar{D}$

$= \bar{A}\,\bar{B}\,CD + \bar{A}\,\bar{B}\,C\bar{D}$

$+ \bar{A}\,BCD + \bar{A}\,B\bar{C}\,D + A\bar{B}\bar{C}D$

$+ A\bar{B}\,\bar{C}\,\bar{D} + AB\bar{C}\,\bar{D}$.

$F = \sum m(2,3,5,7,8,9,12)$

07. Ans: 0.5 (No range)

Sol: Starting current ,$I_{st\ (s,DOL)} = I_{sc}$ (with rated voltage).

With V_1 (Reduced voltage) (40% of V)

$I_{sc1} = 2.5\ I_{f1}$

$0.4V \propto 2.5\ I_{fl}$

$$\frac{0.4V}{V} = \frac{2.5I_{fl}}{I_{sc}}$$

$$I_{sc} = \frac{2.5}{0.4}.I_{fl} = \frac{25}{4}I_{f1}$$

Auto transformer starting line current, $I_{st\ (s,A.T)} = k^2\ I_{st(DOL)}$

$$1.5\ I_{f1} = K^2.\frac{25}{4}.I_{fl}$$

$$K^2 = \frac{1.5\times 4}{25} = \frac{6}{25}$$

Transformation

$$\text{ratio}, K = \sqrt{\frac{6}{25}} = 0.489$$

08. Ans: (A)

Sol: $G(s) = \dfrac{300}{s(s+1)(s+15)(s+20)}$

$$= \frac{300}{s(1+s)15\left(1+\frac{s}{15}\right)20\left(1+\frac{s}{20}\right)}$$

$$= \frac{1}{s(s+1)(1+\frac{s}{15})(1+\frac{s}{20})}$$

Approximate transfer function (considering dominant pole only) of system is

$$G(s) = \frac{1}{s(1+s)}$$

09. Ans: (C)

Sol: In order to eliminate seventh order harmonic, the pulse width is equal to $2d = \dfrac{2\pi}{n}$, $\dfrac{4\pi}{n}, \dfrac{6\pi}{n}, \dfrac{8\pi}{n}, \ldots.$

Hence, $2d = \dfrac{2\pi}{n} = \dfrac{2\pi}{7}$ =51.43, 102.86, 154.3...

10. Ans: (B)

Sol: Find Thevenin's equivalent circuit.

With 2 Ω acting, voltage across it V =6V

With 4Ω acting, voltage across it V=11V

Difference in voltage is 5V

11. Ans: 123 (Range from 120 to 125)

Sol: At no load

$$I_s = C.\frac{V_{sph}}{A}$$

$$|I_s| = \frac{1}{Z_c}\sin\beta\ell.\frac{1}{\cos\beta\ell}.V_{sph}$$

$$\lambda = \frac{3\times10^8}{50}$$

$$= \frac{1}{Z_c}\text{Tan}\,\beta\ell.V_{sph}$$

$$\beta = \frac{2\pi}{\lambda}$$

$$= \frac{1}{400}\times\tan\left(1.047\times10^{-3}\times200\times\frac{180}{\pi}\right)\times\frac{400}{\sqrt{3}}\text{kA}$$

= 0.1227 kA.

12. Ans: (d)

Sol: Generalized Maxwell's equations are

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

2. $\nabla.\vec{D} = \rho_v$

3. $\nabla\times\vec{H} = J_c + \frac{\partial\overline{D}}{\partial t}$

4. $\nabla.\vec{B} = 0$

For static fields $\frac{\partial}{\partial t}(*) = 0$

1. $\nabla\times\vec{E} = 0$

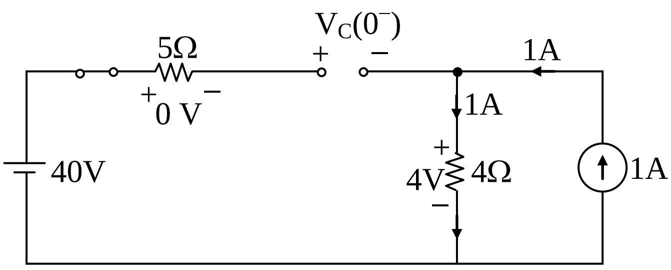
2. $\nabla.\vec{D} = \rho_v$

3. $\nabla\times\vec{H} = J_C$

4. $\nabla.\vec{B} = 0$

13. Ans: 10 (no range)

Sol: Circuit at t = 0^- is

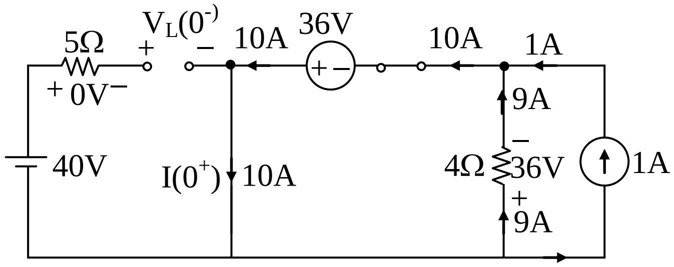


By KVL ⇒ $40 - V_C(0^-) - 4 = 0$

⇒ $V_C(0^-) = 36\text{ V} = V_C(0^-)$

$i_L(0^-) = 0\text{ A} = i_L(0^+)$

Circuit at t = 0^+ is



So, from the circuit $i(0^+) = 10$ A

14. Ans: (A)

Sol: Energy stored $\frac{1}{2}J\omega^2 = 4000\times100$ Nm or Joules

$$\omega = \frac{2\pi\times600}{60} = 20\pi\text{ rad/sec}$$

$$J = \frac{4000 \times 100 \times 2}{(20\pi)^2} = 202.64\ \text{kg} - \text{m}^2$$

For dc motor, the dynamic equation is

$$T_e = J\frac{d\omega}{dt} + T_L$$

$$dt = \frac{J}{T_e - T_L}.d\omega$$

$$t = \frac{J}{T_e - T_L}.\omega$$

Given T_L = motor full load torque, T_{efl}

$$T_{efl} = \frac{100 \times 746}{20\pi}\ \text{N.m}$$

As current during starting is limited to 1.5 time, the full load current, the starting torque.

$T_{est} = 1.5\ T_{efl}$

$$t = \frac{J}{T_{est} - T_{efl}}.\omega = \frac{202.64 \times 20\pi}{0.5 \times 100 \times 746} \times 20\pi$$

t = 21.44 sec

15. Ans: (B)

Sol: $$G(j\omega) = \frac{3(2 - j\omega)}{(j\omega + 1)(j\omega + 5)}$$

$$\Rightarrow M = \frac{3\sqrt{4 + \omega^2}}{\sqrt{\omega^2 + 1}\sqrt{\omega^2 + 25}}$$

$\omega = 0$ magnitude M =1.2

$$\Rightarrow \phi = -\tan^{-1}\left(\frac{\omega}{2}\right) - \tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{5}\right)$$

$\omega = 0$ ------- $\phi = 0°$

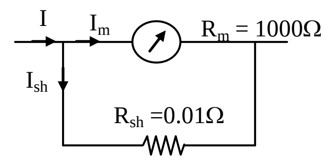
$\omega = \infty$ ------ $\phi = -270°$

The polar starts at $1.2\angle 0°$ and ends at $0\angle -270°$

16. Ans: 0 Reasons $\Rightarrow$ the given wave has half wave symmetry

17. Ans: 40 (No Range)

Sol:



$V_m = V_{sh}$

V_m = 400mV

$$I_{sh} = \frac{V_m}{R_{sh}} = \frac{400 \times 10^{-3}}{0.01}$$

I_{sh} = 40A

18. Ans: (B)

Sol: Relationship between impulse response and step response is

$$h(t) = \frac{d}{dt}s(t)$$

Given, $s(t) = 2e^{-3t}\ u(t)$

$h(t) = 2\ [e^{-3t}\ \delta(t) - 3\ e^{-3t}\ u(t)]$

$\quad = 2e^{-3t}\ \delta\ (t) - 6\ e^{-3t}\ u(t)$

But $e^{-3t}\ \delta\ (t) = 1\ \delta\ (t)$

$\therefore\ h(t) = 2\delta\ (t) - 6\ e^{-3t}\ u(t)$

19. Ans: 10 (no range)

Sol: Given data;

B = 110 MW/Hz

R= 0.01 Hz/MW

D = ?

$$B = D + \frac{1}{R}$$

$$110 = D + \frac{1}{0.01} \Rightarrow D = 10\,\text{MW/Hz}$$

20. Ans: 12

Sol: Given CMRR = 80dB = 10^4 & A_C = 1.5

Step(1):

$$\text{CMRR} = \frac{A_d}{A_c} \Rightarrow A_d = 1.5\times10^4 \_\_\_\_(1)$$

Step(2): $V_o = A_d V_{id} + A_C V_C$___(2)

$\because\ V_{id} = V_1 - V_2$, $\quad V_C = \dfrac{V_1+V_2}{2}$

$$= 1.5\times10^4(100.5-99.5)\text{mV} +$$

$$1.5\left(\frac{100.5+99.5}{2}\right)\text{mV} \_\_\_\_(3)$$

$$= 1.5\times10^4\times1\times10^{-3}\,V + 1.5\times100\times10^{-3}\,V \_\_\_(4)$$

$$= 15.15V \_\_\_(5)$$

NOTE: The maximum possible output voltage in an op-amp circuit is $\le V_{sat}$

$$\therefore V_o = +12V \_\_\_\_(6)$$

21. Ans: (B)

Sol: $$\overline{B} = \nabla\times\overline{A} = \frac{1}{\rho}\begin{vmatrix} \hat{\rho} & \rho\hat{\phi} & \hat{z} \\ \frac{\partial}{\partial\rho} & \frac{\partial}{\partial\phi} & \frac{\partial}{\partial z} \\ \rho^2 & \rho.\frac{\rho}{2} & 0 \end{vmatrix}$$

$$= \frac{1}{\rho}\left[\hat{\rho}(0-0) - \rho\hat{\phi}(0-0) + \hat{z}\left(\frac{2\rho}{2}-0\right)\right]$$

$$= \frac{1}{\rho}[\rho\hat{z}] = \hat{z}\,\text{Wb/m}^2$$

22. Ans: –1 (No Range)

Sol: $$X(z) = \frac{2+3z}{1-z+3z^2} = 2+5z-z^2+-----$$

So, x(–2) = –1

23 Ans: (C)

Sol: $$\frac{dy}{dx} = 4x^3 e^{-y}$$

Using variable separable method

$e^y = x^4 + c$

at x =1, y =0, $\Rightarrow$ c=0

$\Rightarrow e^y = x^4$

24. Ans: (c)

Sol:

LXI B, 0010H	: (BC) ← 0010H
LOOP: DCX B	: (BC) ← (BC)–1
MOV A, B	: (A) ←(B)
ORA C	: (A) ←(A)V(C)
	: This logical operation sets

'Z' Flag

: when (BC) becomes 0000H

JNZ LOOP : Branch to "LOOP" if Z =0

: LOOP will be continued for 16 times

25. Ans: (D)

Sol: $z^2 + 9 = 0 \Rightarrow z = \pm 3i$

z_0 = 3i lies inside the circle.

$$\therefore I = 2\pi i \lim_{z\to 3i} \frac{(z-3i)}{(z+3i)(z-3i)}$$

$$= 2\pi i.\frac{1}{6i} = \frac{\pi}{3}$$

Q. 26 – Q. 55 carry TWO marks each.

26. Ans: 7.07V (Range: 6.5to7.5)

Sol: Vertical sensitivity = 4 V/cm

Peak to peak amplitude = 5 cm

$\therefore V_{p-p}$ = (vertical sensitivity)× (distance between peak to peak)

$V_{pp} = 4 \times 5 = 20V$

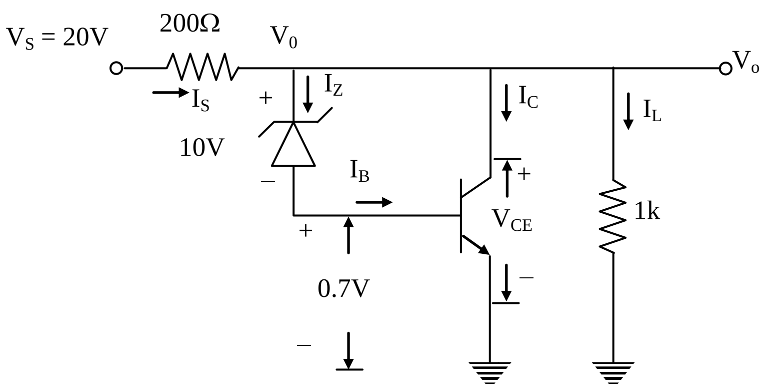
$$V_P = \frac{V_{PP}}{2} = \frac{20}{2} = 10V$$

$$V_{rms} = \frac{V_P}{\sqrt{2}} = \frac{10}{\sqrt{2}}$$

$\Rightarrow V_{rms} = 7.07$ V

27. Ans: 379.26 (Range: 378 to 381)

Sol: **Step (1):** From the circuit, $V_0 = 10V + 0.7V = 10.7V = V_{CE}$ ________(1)



Current through output load resistor

$$\Rightarrow I_L = \frac{V_0}{1k} = 10.7mA \text{ ________(2)}$$

Step (2): KVL for input loop

$$I_S = \frac{20V - 10.7V}{200\Omega} = 46.5mA \text{ ________(3)}$$

Step (3): KCL at node V_0

$I_S = I_Z + I_C + I_L = I_B + I_C + I_L$ ________(4)

$[\because I_B = I_Z]$

$\Rightarrow$

$$I_C\left[1 + \frac{1}{\beta}\right] = 46.5mA - 10.7mA = 35.8mA \text{ ________(5)}$$

$\Rightarrow I_C = 35.445mA$________(6)

Step(4): $P_C = V_{CE} I_C$

= 379.26mW______(7)

28. Ans: 224.17 (Range 222 to 226)

Sol: When source inductance is not taken into account, each diode will conduct for 180°

When source inductance is taken into account, each diode will conduct for $(180 + \mu)°$

Where μ is overlap angle and can be determined as follows:

$$\cos\mu = 1 - \frac{2\omega L_s}{V_m} I_o$$

$$\Rightarrow \cos\mu = 1 - \frac{2 \times 100\pi \times 10 \times 10^{-3}}{220\sqrt{2}} \times 14 = 0.71727$$

$$\Rightarrow \mu = 44.17°$$

$\therefore$ Conduction angle for D_1 is 180 + 44.17

= 224.17°

29. Ans: (B)

Sol: $g(x) = \dfrac{f(x)}{x+1}$

g(x) in continuous and differentiable in [0, 5].

By Lagrange's theorem, there exists a value $c \in (0, 5)$, such that

$$g^1(c) = \frac{g(5)-g(0)}{5-0}$$

$$= \frac{\left(-\frac{1}{6}\right)-4}{5} = \frac{-5}{6}$$

30. Ans: (C)

Sol: $P_{m1} = \dfrac{EV}{X_{eq}} = \dfrac{1.0\times1.0}{0.5} = 2.0$

$P_{m2} = 0$

$P_{m3} = 0.75\ P_{m1} = 1.5$

$\delta_0 = \sin^{-1}\left(\dfrac{P_s}{P_{m1}}\right) = 30$

$\delta_0(\text{rad}) = 0.523$

$\delta_m = 180 - \sin^{-1}\left(\dfrac{P_s}{P_{m3}}\right)$

$= 180 - \sin^{-1}\left(\dfrac{1.0}{1.5}\right) = 138.2^o$

$\delta_m(\text{rad}) = 2.41$

$\delta_c = \cos^{-1}\left(\dfrac{P_s(\delta_m - \delta) + P_{m3}\cos\delta_m}{P_{m3}}\right)$

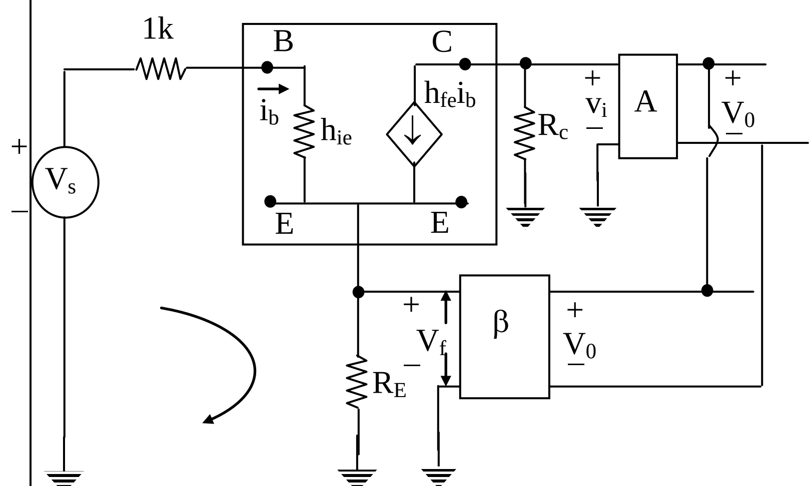
$= \cos^{-1}\left[\dfrac{1.0(2.41-0.523)+1.5\cos138.2)}{1.5}\right]$

$= \cos^{-1}\left[\dfrac{1.0(2.41-0.523)-1.118}{1.5}\right]$

$= \cos^{-1}(0.512) = 59.2^o$

31. Ans: 99.8 (Range: 99 to 100)

Sol:



Small signal model of the given amplifier

Step (1):

From the small signal model shown in fig(a)

$V_i = -h_{fe}i_bR_C$

$= -100\times1k\Omega\ i_b$

$V_o = AV_i$

$= 1000\times100\times1k\ \Omega\ i_b$

$V_f = \beta V_o = \beta AV_i$

$= \dfrac{1}{100}\times(-1000)\times(-100)\times1k\Omega\ i_b$

$= 1000\times1k\Omega\ i_b$

Step (2):

KVL for input loop

$V_s = i_b\ [R_s+h_{ie}]+V_f$

$= i_b[R_s+h_{ie}+1000\times1k\Omega]$

$= i_b[2k\Omega + 1000k\Omega]$

Step (3): $\frac{V_0}{V_s} = \frac{1000 \times 100 \times 1k\Omega i_b}{1002\,k\Omega\, i_b}$

$= 99.8$

32. Ans: (C)

Sol: ω_0 = GCD (4, 12) = 4

$x(t) = 3\sin(\omega_0 t + 20^o) - 4\cos(3\omega_0 t - 40^o)$

$x(t) = 3\sin(\omega_0 t + 20^o) +$

$4\cos(3\omega_0 t + 140^o)$

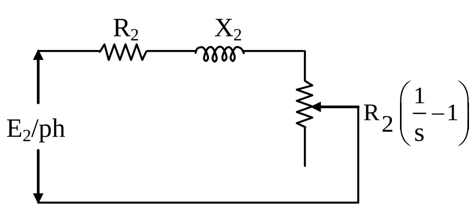
The phase of III harmonic is 140°

33. Ans: 1334 (Range 1130 to 1340)

Sol: Given data, P = 4, V_L = 440 V, $R_2 = 0.1\Omega$,

$X_2 = 0.8\ \Omega$, K = 1.3

For maximum mechanical power output



$$R_2\left(\frac{1}{s}-1\right) = \sqrt{R_2^2 + X_2^2}$$

$$\frac{1}{s} - 1 = \frac{\sqrt{(0.1)^2 + (0.8)^2}}{0.1}$$

$$\frac{1}{s} - 1 = 8.062$$

$$\frac{1}{s} = 9.062$$

s = 0.1103

(i) $N_r = N_s(1 - s)$

$= 1500\ (1 - 0.1103)$

$= 1334$ rpm

34. Ans: (D)

Sol: [A/B]=

$$\begin{bmatrix} 1 & 2 & 3 & 14 \\ 1 & 4 & 7 & 30 \\ 1 & 1 & 1 & \lambda \end{bmatrix} \sim \begin{bmatrix} 1 & 2 & 3 & 14 \\ 0 & 2 & 4 & 16 \\ 0 & 0 & 0 & 2\lambda - 12 \end{bmatrix}$$

To be consistent Rank of augmented matrix (ρ(A/B)) and Rank of A matrix should be equal.

$\rho(A/B) = \rho(A) = 2\lambda - 12 = 0 \Rightarrow \lambda = 6$

35. Ans: (C)

Sol: $x(t) = C_{12}\,(A\cos t)\ 0 < t < 2\pi$

$$C_{12} = \frac{\int_{t_1}^{t_2} x(t)\ A\cos t}{\int_{t_1}^{t_2} (A\cos t)^2\ dt}$$

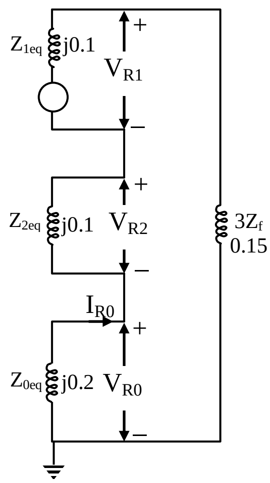
$$= \frac{\int_0^{\pi/2} A^2\cos t + \int_{\pi/2}^{3\pi/2} -A^2\cos t + \int_{3\pi/2}^{2\pi} A^2\cos t}{\int_0^{2\pi} A^2\cos^2 t\ dt}$$

$$C_{12} = \frac{4}{\pi}$$

So, $x(t) = \frac{4A}{\pi}\cos t \quad 0 < t < 2\pi$

36. Ans: (A)

Sol:



$$X_{1eq} = \frac{j0.2}{2} = j0.1$$

$$X_{2eq} = \frac{j0.2}{2} = j0.1$$

$$X_{0eq} = X_0 + 3X_n + 3X_F$$

$$= 0.05 + 3\times 0.05 + 3\times 0.05$$

$$= 0.35$$

$$I_{R_0} = I_{R_1} = \frac{E_{R_1}}{Z_{1_{eq}} + Z_{2_{eq}} + Z_{0_{eq}}}$$

$$= \frac{1.0}{j0.1 + j0.1 + j0.35}$$

$$I_{R_0} = I_{R_1} = \frac{1.0}{j\,0.55} = 1.82\angle -90°$$

$$V_{R_0} = -I_{R_0} X_{0eq} = -1.82\angle -90° \times 0.2\angle 90°$$

$$V_{R_0} = -0.364 = 0.364\text{pu}$$

$$V_{R_0} = 0.364 \times \frac{13.2}{\sqrt{3}} = 2.77\text{kV}$$

37. Ans: (C)

Sol: Number of ways we can distribute 5 red balls into 3 numbered boxes

= C(3–1+5, 5) = 21

Similarly we can distribute 5 white balls in 21 ways and 5 blue balls in 21 ways.

By product rule, required number of ways = (21) (21) (21) = 9261

38. Ans: (B)

Sol: In buck boost converter, $V_T = V_0 + V_{dc} = \frac{V_o}{D}$

$$\left[\because V_o = V_{dc}\left(\frac{D}{1-D}\right)\right]$$

and $I_T = I_L = \frac{I_0}{1-D}$ (symbols have their usual meaning)

Therefore, $\frac{P_0}{P_T} = \frac{V_0 I_0}{\left(\frac{V_0}{D}\right)\times\left(\frac{I_0}{1-D}\right)} = D(1-D)$

It has maximum value at D = 0.5 and the maximum value of 0.25.

39. Ans: (B)

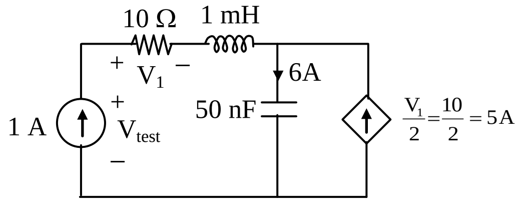
Sol: Total marbles = 10 + 30 + 20 + 15 = 75

P[both are white] = P[first is white and second is white]

$$= \frac{30}{75}\times\frac{30}{75} = \frac{4}{25}$$

40. Ans: (B)

Sol:



$$V_{test} = 10 + j\omega L + \frac{1}{j\omega C}\times 6$$

$$Z_{in} = \frac{V_{test}}{1} = 10 + j\left(\omega L - \frac{6}{\omega C}\right)$$

At resonance, imaginary part of Z_{in} is zero

$$\omega_0 L - \frac{6}{\omega_0 C} = 0$$

$$\omega_0^2 LC = 6$$

$$\omega_0^2 = \frac{6}{LC}$$

$$\omega_0 = \sqrt{\frac{6}{LC}}$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{6}{LC}} = \frac{1}{2\pi}\sqrt{\frac{6}{1m\times 50n}}$$

f_0 = 55 kHz

41. Ans: (D)

Sol: Let voltage drop across the switch = V_t and voltage drop across the diode = V_d

When the switch is ON (0 to DT):

$$L\frac{di_L}{dt} = V_{dc} - V_t$$

When the switch is OFF (DT to $(1-D)T$):

$$L\frac{di_L}{dt} = V_{dc} - V_0 - V_d$$

Apply volt-sec balance equation:

$$(V_{dc} - V_t)DT + (V_{dc} - V_o - V_d)(1-D)T = 0$$

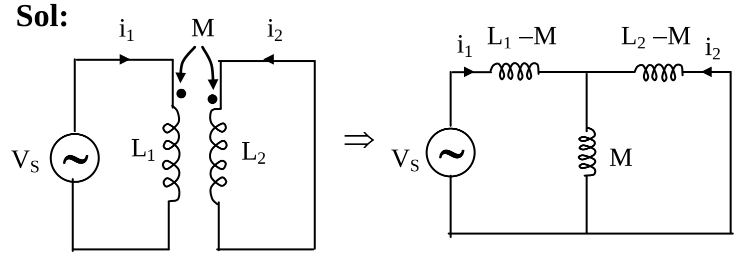
$$\Rightarrow V_0 = \left[\frac{V_{dc}}{1-D}\right]\left[1 - D\frac{V_t}{V_{dc}} - \left(\frac{1-D}{D}\right)\frac{V_d}{V_{dc}}\right]$$

$$\Rightarrow V_0 = \left[\frac{50}{1-0.5}\right]\left[1 - 0.5\times\frac{0.5}{50} - \left(\frac{1-0.5}{0.5}\right)\frac{0.4}{50}\right]$$

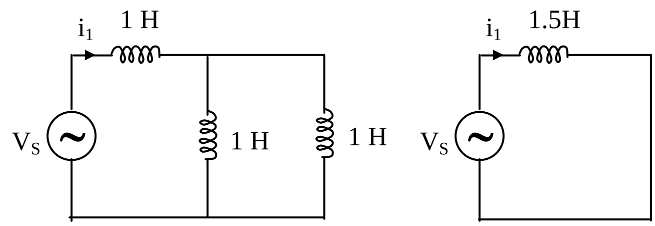
$$= 100\times 0.987 = 98.7V$$

42. Ans: (A)

Sol:



The equivalent circuit is



$$\therefore \text{ Energy stored} = \frac{1}{2}LI^2$$

$$= \frac{1}{2}\times 1.5\times 2^2$$

E = 3J

43. Ans: (c)

Sol:

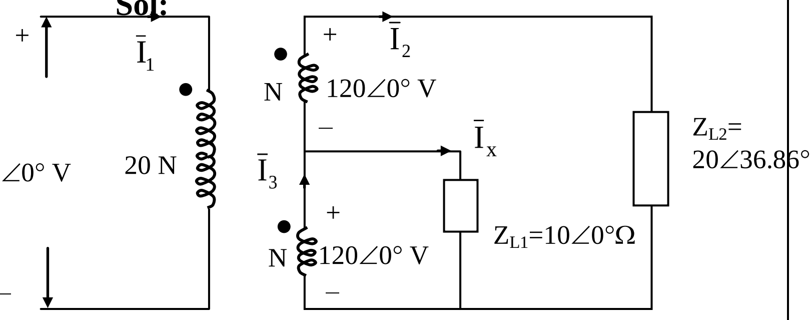


Fig.1

From fig, assuming the transformer to be ideal,

(i) $\bar{I}_2 = \dfrac{240\angle 0°}{20\angle 36.86°}$

$= 12\angle -36.86° = 9.6 - j7.2\text{A}$

(ii) $\bar{I}_x = \dfrac{120\angle 0°}{10\angle 0°} = 12\angle 0°\text{A}$

$\bar{I}_x = \bar{I}_3 - \bar{I}_2 \Rightarrow 12\angle 0° = \bar{I}_3 - 12\angle -36.86$

$\Rightarrow \bar{I}_3 = 21.6 - j7.2\,\text{A}$

(iii) The number of turns of each winding must be as marked in the fig.

For Amp-turn balance,

$\bar{I}_1(20\text{N}) = (\bar{I}_2\text{N}) + (\bar{I}_3\text{N})$ …….. (1)

(Since $\bar{I}_1$ enters its winding at dot and $\bar{I}_2$ and $\bar{I}_3$ leave their respective windings at dots, a component of $\bar{I}_1$ must be in phase with $\bar{I}_2$ and another component of $\bar{I}_1$ must be in phase with $\bar{I}_3$ by dot convention).

$\bar{I}_1 = \dfrac{\bar{I}_2 + \bar{I}_3}{20} = \dfrac{1}{20}[31.2 - j14.3]\text{A}$

$= 1.718\angle -24.76°$ A

Magnitude = 1.718

Power factor = 0.908

44. Ans: (D)

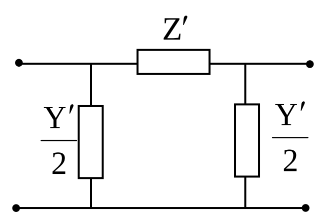
Sol: It is a 3 bit shift Register, for each clk pulse

$Q_3 \rightarrow Q_1$, $Q_3 \odot Q_1 \rightarrow Q_2$, $Q_2 \rightarrow Q_3$

Clk	Q_1	Q_2	Q_3
0	0	0	0
1	0	1	0

45. Ans: 459.8 (Range: 457.50 – 461.50)

Sol:



Line constants are L = 1 mH/km

C = 9.7 nF/km

Length of transmission line, l = 300 km

Let us take equivalent – π model in standard form.

In this model $\dfrac{Y'}{2}$ has to be calculated

For this model $A = 1 + \dfrac{Z'Y'}{2}, B = Z'$

From these two equation, $\dfrac{Y'}{2} = \dfrac{A-1}{B}$

Where 'A' and 'B' for lossless long line given in the data. For lossless long line. A = $\cos\beta l$, B = $jz_c \sin\beta l$

$$\beta = \omega\sqrt{LC} = 2\pi\times 50\times\sqrt{1\times10^{-3}\times 9.7\times10^{-9}}$$

$= 0.978\times10^{-3}$ rad/km

$$Z_c = \sqrt{\frac{L}{C}} = \sqrt{\frac{1\times10^{-3}}{9.7\times10^{-4}}} = 321.08\Omega$$

Now for line, A = cos $(0.978\times10^{-3}\times300)$

= 0.9573

B = j 321.08 × $\sin(0.978\times10^{-3}\times 300)$

= j92.86Ω

$$\frac{Y'}{2} = \frac{A-1}{B} = j4.598\times10^{-4}\,℧$$

From given model $\frac{Y'}{2} = jB$

$\Rightarrow$ B = 459.8μ℧ = 459.8μ℧

46. Ans: 0.5

Sol: CE is $|SI - A| = 0$

$$\begin{vmatrix} s & -1 & 0 \\ 0 & s & -1 \\ 1 & k & s+2 \end{vmatrix} = 0$$

$s[s^2 + 2s + k] + [1] = 0$

$s^3 + 2s^2 + sk + 1 = 0$

RH criteria

$$\begin{array}{c|cc} s^3 & 1 & k \\ s^2 & 2 & 1 \\ s^1 & \frac{2k-1}{2} & \\ s^0 & 1 & \end{array}$$

The value of k for system becomes just stable is

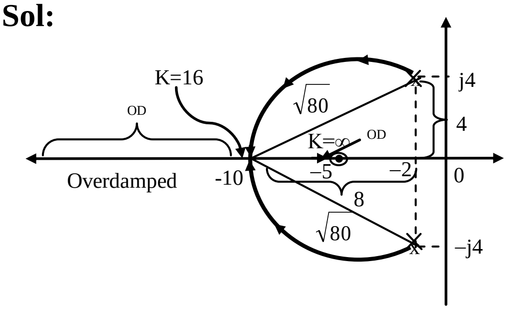
$2k - 1 = 0$

$2k = 1$

$\therefore$ k = 1/2

47. Ans: (B)

Sol:



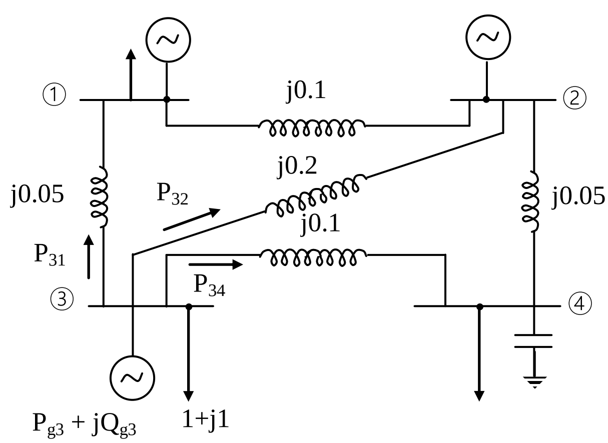
$$K\Big|_{s=s_1} = \frac{\text{Product of distance vectors from various poles of } G(s)H(s) \text{ to } s = s_1}{\text{Product of distance vectors from various zeroes of } G(s)\,H(s) \text{ to } s = s_1}$$

$$k = \frac{\sqrt{80}\times\sqrt{80}}{5} = 16$$

K > 16 the system is over damped.

48. Ans: Range: [6.60 to 7.05]

Sol:



X_{ij} = reactance of line connected between bus 'i' and 'j'

$V_1\angle\delta_1 = 1\angle 0°$; $V_3\angle\delta_3 = 0.98\angle 8°$

$V_2\angle\delta_2 = 0.95\angle 10°$; $V_4\angle\delta_4 = 1.05\angle -10°$

$$P_{31} = \frac{V_3V_1}{X_{31}}\times\sin(\delta_3-\delta_1)$$

$$P_{31} = \frac{0.98\times 1}{0.05}\times\sin(8^o-0^o)$$

P_{31} = 2.7278 pu

$$P_{32} = \frac{V_3V_2}{X_{32}}\times\sin(\delta_3-\delta_2)$$

$$= \frac{0.98\times 0.95}{0.2}\times\sin(8^o-10^o)$$

P_{32} = –0.1624 pu

$$P_{34} = \frac{V_3V_4}{X_{34}}\times\sin(\delta_3-\delta_4)$$

$$P_{34} = \frac{0.98\times 1.05}{0.1}\times\sin[8^o-(-10^o)]$$

P_{34} = 3.1798 pu

Active power balance at bus ③

$P_{g3} = P_{32} + P_{31} + P_{34} + P_{load3}$

= 2.7278 – 0.1624 + 3.1798 + 1

P_{g3} = 6.7452

49. Ans: 2.203 (2.0 to 2.3)

Sol: $Z_{in} = j\omega L \parallel \left(R+\frac{1}{j\omega C}\right)$

$$Z_{in} = \frac{j\omega L\left(R+\frac{1}{j\omega C}\right)}{R+j\omega L+\frac{1}{j\omega C}} = \frac{\frac{L}{C}+j\omega LR}{R+j\left(\omega L-\frac{1}{\omega C}\right)}$$

$$Z_{in} = \frac{\left(\frac{L}{C}+j\omega LR\right)\left(R-j\left(\omega L-\frac{1}{\omega C}\right)\right)}{R^2+\left(\omega L-\frac{1}{\omega C}\right)^2}$$

To have a resistive impedance, $Im(Z_{in}) = 0$. Hence,

$$\omega LR^2-\left(\frac{L}{C}\right)\left(\omega L-\frac{1}{\omega C}\right)=0$$

$\omega R^2C = \omega L - 1/\omega C$

$\omega^2R^2C^2 = \omega^2LC - 1$

$$L = \frac{\omega^2R^2C^2+1}{\omega^2C}$$

Now we can solve for L.

$L = R^2C + 1/(\omega^2C)$

$=(200^2)(50\times10^{-9})+1/[(2\pi\times50,000)^2(50\times10^{-9})]$

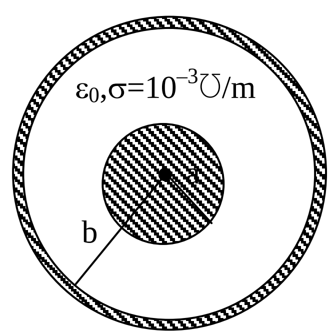
$= 2\times10^{-3} + 0.2026\times10^{-3}$

= 2.203mH

50. Ans: 1.515 (1.45 to 1.65)

Sol: Capacitance between two concentric spheres is

$$C = \frac{4\pi\varepsilon ab}{b-a}$$



and conductance is given as

$$G = \frac{\sigma}{\varepsilon} C$$

$$\therefore R = \frac{1}{G} = \frac{\varepsilon}{\sigma C} = \frac{\varepsilon(b-a)}{\sigma 4\pi\varepsilon ab}$$

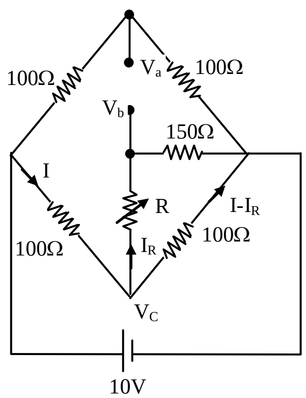
$$\therefore R = \frac{b-a}{4\pi\sigma ab} = \frac{(7-3)\times 10^{-2}}{4\pi \times 10^{-3} \times 21 \times 10^{-4}}$$

$$= 1515.76\Omega$$

$$= 1.515k\Omega$$

51. Ans: 50.1Ω [49 to 51]

Sol: When bridge is balanced $V_a = V_b$



$$V_a = \frac{10\times 100}{200} = 5V$$

$V_a = V_b = 5V$

$$I_R = \frac{V_b}{150} = \frac{1}{30} A$$

$$10 - 100I - 100\left(I - \frac{1}{30}\right) = 0$$

$$I = \frac{1}{15} A$$

$$V_c = \left[\frac{1}{15} - \frac{1}{30}\right] \times 100 = 3.33V$$

$$|R| = \frac{V_b - V_c}{I_R} = \frac{5-3.33}{\left[\frac{1}{30}\right]} = 50.1\Omega$$

52. Ans: 0.75

Sol: $\text{TF} = L[IR] = \dfrac{2}{(s+2)^2 + 2^2}$

$$= \frac{2}{s^2+4s+8} = \frac{C(s)}{R(s)}$$

Steady state error $(e_{ss}) = \underset{t\to\infty}{Lt}\, e(t)$

$$= \underset{s\to 0}{Lt}\, sE(s)$$

$$= \underset{s\to 0}{Lt}\, s\left[R(s) - C(s)H(s)\right]$$

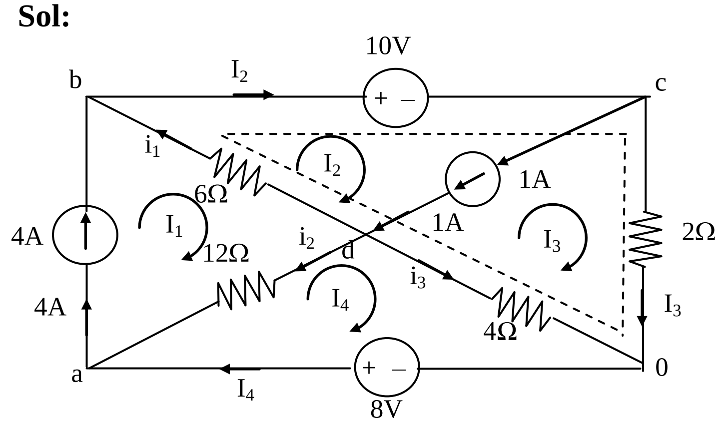
$e_{ss} = \underset{s\to 0}{Lt}\, s\left[R(s) - C(s)\right]$ $[\because H(s) = 1]$

$$= \underset{s\to 0}{Lt}\, s\left[\frac{1}{s} - \frac{2}{s^2+4s+8} \times \frac{1}{s}\right]$$

$$= 1 - \frac{1}{4} = \frac{3}{4} = 0.75$$

53. Ans: 2 (No range)

Sol:



It is evident that $I_1 = 4$ ………. (1)

For mesh 4, $12(I_4 - I_1) + 4(I_4 - I_3) - 8 = 0$ ..(2)

For the super mesh

$6(I_2 - I_1) + 10 + 2I_3 + 4(I_3 - I_4) = 0$

or

$-3I_1 + 3I_2 + 3I_3 - 2I_4 = -5$ …….. (3)

At node c, $I_2 = I_3 + 1$ ……… (4)

Solving (1), (2), (3) and (4) yields

$I_1 = 4$ A, $I_2 = 3$ A, $I_3 = 2$ A, and $I_4 = 4$ A

At node b, $i_1 = I_2 - I_1 = -1$ A

At node a, $i_2 = 4 - I_4 = 0$ A

At node 0, $i_3 = I_4 - I_3 = 2$ A

$i_2 + i_3 = 0 + 2 = 2$A

54. Ans: 6. 7 (Range: 6 to 7)

Sol: When a 3-phase synchronous machine is operating on an infinite bus, we can show that

P = power per phase

$$= \frac{EV}{X_d}\sin\delta + \frac{V^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta$$

Where all symbols have their usual meanings.

The term $\frac{V^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta$ is called the reluctance power P_{rel}. It exist even when there is no excitation; but it is non zero only for salient pole machines where $X_d > X_q$. (For non-salient pole rotor machines, $X_d = X_q = X_s$ = synchronous reactance).

In the problem; P_{rel}/ph = $\frac{V^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta$.

For maximum P_{rel}(as δ varies); $\frac{dp_{rel}}{d\delta} = 0$.

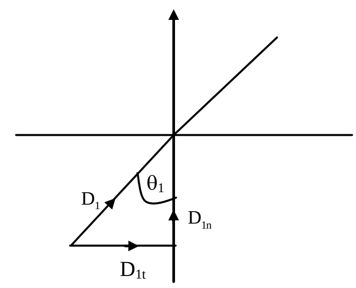
Which gives $\delta = \left(\frac{\pi}{4}\right)$rad.

P_{rel}/ph = $\frac{1}{2}\left(\frac{400}{\sqrt{3}}\right)^2\left(\frac{1}{4} - \frac{1}{6}\right)$W.

Maximum reluctance power fall 3 phases = 6666.66

55. Ans: (a)

Sol:



From boundary condition, $D_{1n} = D_{2n}$ and

$\frac{D_{1t}}{D_{2t}} = \frac{\varepsilon_1}{\varepsilon_2}$ or $D_{2t} = \frac{\varepsilon_2}{\varepsilon_1}D_{1t}$

$D_{1n} = D_1\cos\theta_1$ and $D_{1t} = D_1\sin\theta_1$, where $D_1 = |\overline{D}_1|$.

Hence $D_{2n} = D_1\cos\theta_1$

$$D_{2t} = \frac{\varepsilon_2}{\varepsilon_1}D_{1t} = \frac{\varepsilon_2}{\varepsilon_1}D_1\sin\theta_1$$

Now

$$D_2 = \sqrt{(D_{2n})^2 + (D_{2t})^2}$$

$$= \sqrt{(D_1\cos\theta_1)^2 + \left(\frac{\varepsilon_2}{\varepsilon_1}D_1\sin\theta_1\right)^2}$$

$$= D_1\sqrt{\cos^2\theta_1 + \left(\frac{\varepsilon_2}{\varepsilon_1}\sin\theta_1\right)^2}$$