Level-I

Q1 (a) It is given in theoretical part

Q2. (b) $E = E_0 \cos\omega t \Rightarrow E = 10\cos\omega t$
$= 10\cos 2\pi(50)\frac{1}{600}$
$= 10\cos\frac{\pi}{6}$
$= 5\sqrt{3}$ Volt

Q3. (b) Power consumed $= V_{rms} i_{rms} \cos\phi = \frac{1}{2} V_{rms} i_{rms}$
$\Rightarrow \cos\phi = \frac{1}{2} \Rightarrow \phi = \frac{\pi}{3}$

Q4 (b) $X_C = \frac{1}{\omega C} \Rightarrow$ more the value of ω is less is the value of X_C

Q5 (d) ~~Since~~ power loss increases with resistance, also less the value of power factor $\cos\phi = \frac{R}{\sqrt{R^2+X_L^2}}$ less is the power loss, so (d) is true

Q 6 (d) The time taken will be $\frac{1}{4}$th of one cycle which is $\frac{1}{4}\left(\frac{1}{50}\right)$ sec $= 5\times10^{-3}$ sec.

Q 7 (d) peak value $= \sqrt{2}\, i_{rms} = 14.14$ Amp.
Time taken is $\frac{1}{4}$th of one cycle $= \frac{1}{4}\left(\frac{1}{50}\right) = 5\times10^{-3}$ sec.

Q8 (c) ratio $= \frac{V_0}{V_0/\sqrt{2}} = \sqrt{2}$

Q9 (a) average value over one cycle is always zero.

Q10 (a) average value over +ve half cycle $= \frac{2}{\pi}V_0 = \frac{2}{\pi}V_{rms}\sqrt{2}$
$= 198$ Volt

Q11 (c) $X_L = \omega L = 2\pi f L = 2\pi(50)\frac{1}{\pi} = 100\,\Omega$

Q12 (b) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{120}{\sqrt{2}} = 84.8$ Volt

Q13 (b) $P = \frac{V_{rms}^2}{R} = 90$ Watt

Q14 (d) $X_L = 2\pi f L = 50\,\Omega \Rightarrow L = \frac{50}{2\pi f} = \frac{50}{2(3.14)(50)} = 0.16$ H

Q15 (b) for d.c $\omega = 0 \Rightarrow X_C = \frac{1}{\omega C} = \infty$

Q16 d b $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{4}{\sqrt{2}} = 2\sqrt{2}$ Amp.

Q17 (a) Since phase difference between V and i is 90° the power dissipated is $V_{rms} i_{rms} \cos 90 = 0$

Q18 (d) $P = \frac{1}{2}V_0 i_0 \cos\phi$ and we do not no ϕ so P cannot be calculated

19(c) $\langle P \rangle = \frac{1}{2} e_0 i_0 \cos\phi = \frac{1}{2}(200)(1)\cos\frac{\pi}{3} = 50$ Watt.

20(c) $V_0 = V_{rms}\sqrt{2} = 220\sqrt{2} = 311$ Volt.

21 (d) It represents rms voltage.

22 (d) phase difference is $90°$ => Average power dissipated $= 0$

23(a) It is $90°$ (by theory)

24(c)
$$i = i_1 \cos\omega t + i_2 \sin\omega t$$
$$= \sqrt{i_1^2+i_2^2}\left[\frac{i_1}{\sqrt{i_1^2+i_2^2}}\cos\omega t + \frac{i_2}{\sqrt{i_1^2+i_2^2}}\sin\omega t\right]$$
$$i = \sqrt{i_1^2+i_2^2}\,\sin(\omega t+\phi)$$
$$i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{\sqrt{i_1^2+i_2^2}}{\sqrt{2}}$$

25(a) $\langle i \rangle = 0$ for a complete cycle

26(c) $V_{rms} = \frac{240}{\sqrt{2}} = 120\sqrt{2} \approx 170$ Volt
$2\pi f = 120 \Rightarrow f = \frac{120}{2\pi} \approx 19$ Hz.

27 (b) $\frac{V_m}{V_{rms}} = \frac{\frac{2}{\pi}V_0}{\frac{V_0}{\sqrt{2}}} = \frac{2\sqrt{2}}{\pi}$

28 (c) peak to peak value $240 - (-240) = 480$ Volt.

29(a) $e = e_0 \sin 2\pi(50)t$
now $e = \frac{e_0}{\sqrt{2}} \Rightarrow \frac{e_0}{\sqrt{2}} = e_0 \sin 100\pi t \Rightarrow \sin 100\pi t = \frac{1}{\sqrt{2}}$
$\Rightarrow 100\pi t = \frac{\pi}{4}$
$\Rightarrow t = \frac{1}{400}$ sec $= 2.5$ ms

30 (b)
$$P_0 = V_{rms}\, i_{rms} \cos\phi$$
$$600 = (160)(5)\cos\phi$$
$$\cos\phi = \frac{3}{4} = 0.75$$

31 (d) It will be zero because voltage across L and C are $180°$ out of phase and have to be subtracted, voltage across L-C combination will be $V_{LC} = V_L \sim V_C = 0$

32(a) $\omega = \frac{1}{\sqrt{LC}}$, if C is doubled, L has to be halved to get same value of ω.

33(b) Read theory.

34(d) Impedence $Z = \sqrt{R^2+X^2} = \sqrt{8^2+6^2} = 10\,\Omega$

35(d) i is maximum when circuit is in resonance ie $\omega = \frac{1}{\sqrt{LC}}$

36(d) $Z = \sqrt{R^2+X_L^2} = \sqrt{12^2+16\pi^2} \approx 17.4\,\Omega$
$i = \frac{V}{Z} = \frac{220}{17.4} \approx 12.7$ Amp

37 (a) In pure capacitive circuit current is ahead in phase by 90°

38 (c) $\tan\phi = \frac{\omega L}{R} = \frac{50(.1)}{5} \Rightarrow \phi = \frac{\pi}{4}$

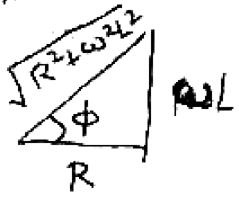
39 (c) $\tan\phi = \frac{\omega L}{R} = \frac{2\pi f L}{R} = \frac{2\pi\left(\frac{200}{2\pi}\right)(1)}{200} = 1 \Rightarrow \phi = \frac{\pi}{4}$

40 (a) $i_0 = \frac{V_0}{R} = \frac{V_{rms}\sqrt{2}}{R} = \frac{200\sqrt{2}}{280} \approx 1$ Amp

41 (b) $Z = \sqrt{R^2 + \omega^2 L^2} = \sqrt{100 + (240\pi)^2} \approx 240\pi$

$i = \frac{V}{Z} = \frac{120}{240\pi} = \frac{1}{2\pi} \approx 0.16$ Amp

42 (b) $\cos\phi = \frac{R}{\sqrt{R^2+\omega^2L^2}}$



43 (a) $X_C = \frac{1}{\omega C}$

$25 = \frac{1}{\left(\frac{400}{\pi}\right)2\pi C} \Rightarrow C = 50 \times 10^{-6}\,F = 50\,\mu F$

44 (d) Nett reactance $= 25 - 18 = 7\,\Omega$

$Z = \sqrt{11^2 + 7^2} = \sqrt{170} \approx 13\,\Omega$

$i = \frac{V}{Z} = \frac{260}{13} = 20$ Amp

45 (b) Refer theory.

46 (d) Since $X_L = X_C \Rightarrow$ Reactance $= 0$

$\Rightarrow$ Nett impedence $= R$

current $i = \frac{V}{R} = \frac{240}{30} = 8$ Amp.

47 (c) $Z = \sqrt{R^2 + (2\pi f L)^2} = \sqrt{40^2 + (2 \times 3.14 \times 50 \times 95.5 \times 10^{-3})^2}$

$\approx 50\,\Omega$

48 (b)(c) $\cos\phi = \frac{R}{\sqrt{R^2+\omega^2L^2}}$, $\cos\phi = 1$ only when $L = 0$ & $\cos\phi = 0$ when $R = 0$

49 (a) $Z = \omega L = 2\pi f L = 2\pi(50)(1) = 314\,\Omega$

$i = \frac{V}{Z} = \frac{200}{314} \approx 0.637$ Amp.

50 (d) $Q = \frac{\omega L}{R} \rightarrow$ refer theory

Level 2

Q1. (b) $P = V_{rms} i_{rms} \cos\phi$

$1000 = 100\sqrt{2}\, i_{rms} \frac{1}{2} \Rightarrow i_{rms} = 10\sqrt{2}$ A

Q2. (b) Phase diff $\phi = (314t - \frac{\pi}{6}) - 314t = -\frac{\pi}{6}$

Q3 (b) current is ahead in phase, so it is represented by (b)

Q4 (c) $i_{rms} = \sqrt{\frac{\int i^2 dt}{\int dt}} = \sqrt{\frac{\int_2^4 4t\, dt}{\int_2^4 dt}} = \sqrt{\frac{2t^2 \Big|_2^4}{t \Big|_2^4}} = \sqrt{12}$

$= 2\sqrt{3}$

Q5 (a) it is the combination of a.c and d.c.

its rms value will be $\sqrt{i_0^2 + \left(\frac{i_1}{\sqrt{2}}\right)^2} = \sqrt{i_0^2 + 0.5\, i_1^2}$

Q6(b) for a.c. circuit ammeter the marks on scale are not evenly spaced as $\theta \propto i^2$ so b is correct.

Q7(b) As same heat is produced in both cases

$i^2 R = i_{rms}^2 R \Rightarrow i = i_{rms} = \frac{14}{\sqrt{2}} \approx 10$ A

Q8(c) $i = 10 \sin 314t \Rightarrow i^2 = 100 \sin^2 314t$

Av value of $i^2 \Rightarrow \frac{\int i^2 dt}{\int dt} = \frac{100 \int_0^T \sin^2 314t\, dt}{\int_0^T dt}$ where $T = \frac{2\pi}{\omega} = \frac{1}{50}$ sec.

$\langle i^2 \rangle = 50\ A^2$

Q9 (d) it will be 4 A because when -4 is squared we get 16 so the average of 4^2 and $(-4)^2$ are same and rms value will be 4

Q10 (b) rms value of $x_0 \sin\omega t = \frac{x_0}{\sqrt{2}}$, rms value of $x_0 \sin\omega t \cos\omega t$ i.e of $\frac{x_0}{2} \sin 2\omega t$ is $\frac{x_0}{2\sqrt{2}}$, rms value of $x_0 \sin\omega t + x_0 \cos\omega t$ is $\sqrt{\frac{x_0^2 + x_0^2}{2}} = x_0$

11(b) Second cable is more suitable since a.c. flows on the surface of wire

12(c) $X_c = \frac{1}{\omega C} = \frac{1}{314\left(\frac{10^{-4}}{314}\right)} = 10^4 \Omega$

$V = i X_c \cos(314t + 30° - 90°) = 25\times10^{-3}\times10^4 \cos(314t - 60°)$
$= 250 \cos(314t - 60°)$ Volt
$= 250 \sin(314t + 30°)$ Volt

13(a) $V_{mains}^2 = V_R^2 + V_L^2$
$(100)^2 = 10^2 + V_L^2 \Rightarrow V_L = \sqrt{9900} = 10\sqrt{99}$ Volt $= i\omega L$
$V_R = iR$

$\frac{V_L}{V_R} = \frac{\omega L}{R} \Rightarrow \frac{10\sqrt{99}}{10} = \frac{2\pi(50) L}{(10^2/60)} \Rightarrow \sqrt{99} = \pi L(60)$
$\Rightarrow L = 0.052$ H

14(d) $P_{in} = V_0 i_0 \sin\omega t \cos\omega t$
$= \frac{1}{2} V_0 i_0 \sin 2\omega t$

So angular frequency will be 2ω

15(c) Since the current is leading the components are R and C.

16(c) from the diagram, current is lagging, so it is either L-R or LCR $\left[\omega L > \frac{1}{\omega C}\right]$

17(b) Resistance $R = \frac{V}{i} = 15\Omega$ [when D.C is flowing]
when a.c. is flowing
$Z = \frac{V_{ac}}{i_{ac}} = \frac{30}{1.2} = 25\Omega = \sqrt{R^2 + X_L^2}$
$\Rightarrow X_L = 20\Omega$

18(c) $V_1^2 + V_L^2 = 5^2 = 25 \Rightarrow 3^2 + V_2^2 = 25 \Rightarrow V_2 = 4$ Volt

19(c) The reactances X_L and X_C cancell out, only resistance remains, ammeter reading will be $i = \frac{V}{R} = \frac{110}{55} = 2$ A.

20(c) It is at R because at R X_L and X_C can cancel each other.

21(a) Initially $I = \frac{V}{Z} = \frac{V_0}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$ —— ①

after frequency becomes $\frac{\omega}{3} \Rightarrow \frac{I}{2} = \frac{V_0}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}}$ —— ②

dividing ① by ②
$\left(\frac{I}{I/2}\right) = \frac{\cancel{V_0}}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} \frac{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}}{\cancel{V_0}} \Rightarrow 2^2 = \frac{R^2 + \frac{9}{\omega^2 C^2}}{R^2 + \frac{1}{\omega^2 C^2}}$
$\Rightarrow 4R^2 + \frac{4}{\omega^2 C^2} = R^2 + \frac{9}{\omega^2 C^2}$
$\Rightarrow 3R^2 = \frac{5}{\omega^2 C^2}$
$\Rightarrow 3R^2 = 5 X_C^2$
$\Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$

2.2 (b) Read theory

23 $P = V_{rms} i_{rms} \cos\phi \Rightarrow 550 = 220\, i_{rms} (.8) \Rightarrow i_{rms} = \frac{25}{8}$ A

now $Z = \frac{V_{rms}}{i_{rms}} = \frac{220}{25/8} = 70 = \sqrt{R^2+X_L^2} \Rightarrow R^2+X_L^2 = 4900$ —①

also $\cos\phi = .8 \Rightarrow \tan\phi = \frac{3}{4} = \frac{X_L}{R} \Rightarrow X_L = \frac{3}{4}R$ —② | from ① & ② $R = 56\,\Omega$ and $X_L = 42\,\Omega$

so $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = 42 \Rightarrow C = \frac{1}{2\pi f(42)} = \frac{1}{2(3.14)(50)42} = 75.4$

24 (a) sharpness is given by $\frac{\omega L}{R}$ so as R decreases, sharpness increases

25 (b) It happens when the circuit is in resonance i.e.

$$\omega L = \frac{1}{\omega C} \Rightarrow \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{1}{\pi}\,\frac{1}{\pi}\times 10^{-6}}} = 1000\pi$$

$$2\pi f = 1000\pi \Rightarrow f = 500\text{ Hz}$$

26 (b) for $f=0$ circuit behaves as open circuit because the current is d.c. in nature, for $f=\infty$, current drops to zero because the inductive reactance increases to ∞

27 (a) Nett impedence $Z = \sqrt{R^2+(\omega L - \frac{1}{\omega C})^2} = \sqrt{6^2+\left[2000\times 5\times 10^{-3} - \frac{1}{2000(50\times 10^{-6})}\right]^2}$

$$= \sqrt{6^2+[10-10]^2} = 6\,\Omega$$

$$i_{rms} = \frac{20}{\sqrt{2}}\,\frac{1}{6} = \frac{10\sqrt{2}}{6} \approx 2\text{A}$$

28 (d) By given conditions $X_L = X_C$ so average power dissipated is $\langle P\rangle = \frac{1}{2} V_0 i_0 \cos 0 = \frac{1}{2} V_0 i_0 = \frac{1}{2}\frac{V_0^2}{R}$ $\cancel{= \frac{1}{2}\frac{(200)^2(\sqrt{2})^2}{100}}$

$$= \frac{1}{2}\frac{(V_{rms}\sqrt{2})^2}{R} = \frac{V_{rms}^2}{R} = \frac{200^2}{100} = 400\text{ Watt}$$

29 (c) Power factor $\cos\phi = \frac{R}{\sqrt{R^2+\left(\frac{1}{2\pi f C}\right)^2}}$

$$= \frac{3000}{\sqrt{3000^2+4000^2}} = \frac{3}{5} = 0.6$$

$$\langle P\rangle = V_{rms} i_{rms} \cos\phi$$

$$= 200\left(\frac{200}{5000}\right)(.6) = 4.8\text{ Watt}$$

30 (b) Voltage across the coil (Resistance) $= \frac{240}{4} = 60$ Volt.

now voltage across inductive part $V_L^2 = V^2 - V_R^2 = 100^2 - 60^2$

$V_L = 80$ volt $= i\,2\pi f L$

$$80 = 4(2\pi)(50)L \Rightarrow L = \frac{1}{5\pi}\text{ Hz}$$

31 (a) with increase in ω, impedence $Z = \sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}$ decreases so current increases and the bulb will give more intense light

32 (b) $V_{source}^2 = V_R^2 + V_C^2 \Rightarrow 220^2 = 110^2 + V_C^2 \Rightarrow V_C^2 = 220^2 - 110^2 = 48400 - 12100$

$V_C \approx 190$ Volt

33(b) P.d. across resistance = iR = 60 volt

now $V_{source}^2 = V_R^2 + V_C^2$

$100^2 = 60^2 + V_C^2 \Rightarrow V_C = 80$ Volt.

34(b) Impedence $Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2} = \sqrt{(10^4)^2 + \left(\frac{1}{100 \times 10^{-6}}\right)^2} = 10^4\sqrt{2}\ \Omega$

$i = \frac{V_{rms}}{Z} = \frac{200}{10^4\sqrt{2}} = 10\sqrt{2}$ mA

35 (c) Q factor $= \frac{5000}{500} = 10$

36 (b) Impedence $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + (R - \frac{R}{2})^2} = \frac{\sqrt{5}}{2} R$

$\phi = \tan^{-1} \frac{X_L - X_C}{R} = \tan^{-1} \frac{R - \frac{R}{2}}{R} = \tan^{-1} \frac{1}{2}$

37 (a) $V_{supply} = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{V_R^2 + (3V_R - 2V_R)^2} = V_R\sqrt{2}$

38 (d) according to conditions $X_L = X_C$ and the original circuit is purely resistive, so the current is $i_{rms} = \frac{V_{rms}}{R} = \frac{200}{100} = 2$ Amp

39 (a) Since $V_L = V_C$, circuit is purely resistive, so $i = \frac{V}{R} = \frac{100}{50} = 2$ A and $V = 100$ Volt because complete voltage is across resistance.

40 (a) At resonance $V_3 = V_1$ because V_2 is zero.

41 (d) At resonace combined p.d. of inductance and capacitance is zero so V_4 is zero

42 (a) At resonance circuit behaves as pure resistive circuit so $\phi = 0$

now $i_0 = \frac{V_0}{R} = \frac{100}{100} = 1$ Amp.

$\langle P \rangle = \frac{1}{2} V_0 i_0 \cos\phi = \frac{1}{2}(100)(1)\cos 0 = 50$ Watt

43 (a) During resonance $i_C + i_L = 0$

and i_R = Source current $\Rightarrow$ reading of A_4 = reading of A_3

44 (b) See theory.

Previous year's questions

Q 2(a) Since the phase difference is same in both cases hence the effect of inductive reactance and capacitive reactances are same so nett circuit is resistive hence power factor is one.

Q 3(d) $\langle P \rangle = \frac{1}{2} V_0 i_0 \cos\phi = \frac{1}{2} \frac{1}{\sqrt{2}} \frac{1}{\sqrt{2}} \cos\frac{\pi}{3} = \frac{1}{8}$ Watt.

Q 4(c) $\langle P \rangle = \frac{1}{2} V_0 i_0 \cos\phi = \frac{1}{2}(150)(150)\cos\frac{\pi}{3} = 5625$ Watt Q 1(a)

Q 5(a) value of d.c. = 3 A
rms value of a.c. = 4 A
when both operate simultaniously $\Rightarrow i_{nett} = \sqrt{3^2+4^2} = 5$ A.

Q 6 $e = e_0 \sin\omega t = 120 \sin 2\pi f.t$
$e = 120 \sin 120\pi t$
$= 120 \sin 120\pi \frac{1}{720} = 120 \sin\frac{\pi}{6} = 60$ Volt

Q 7(c) See theory.

Q 8 (a) option is a because at low current, energy loss during transmission is very less.

Q 9(c) $\langle P \rangle = \frac{1}{2} E_0 I_0 \cos\phi$

Q 10(c) correct option is (c), the indicator needle does not get time to change its direction in very short time intervals due to inertia

Q 11(d) $\cos\phi = \frac{R}{Z}$, when Z becomes double power factor becomes half (keeping R constant), so Z increases by 100%

Q 12 (b) Since $X_C = \frac{1}{\omega C}$ so as ω increases X_C decreases.

Q 13 (d) peak value $i_0 = 10\sqrt{2}$ Amp [because $i_{peak} = i_{rms}\sqrt{2}$]

Q 14 $\cos\phi = \frac{R}{Z} = \frac{1}{\sqrt{3}} \Rightarrow \phi = \cos^{-1}\frac{1}{\sqrt{3}}$

Q 15 (d) Since the phase difference is $\phi = \frac{\pi}{2}$, power factor $\cos\phi = 0$ hence the power consumed per cycle = 0

Q 16 (b) $\langle P \rangle = \frac{1}{2} V_0 i_0 \cos 0 = \frac{1}{2}(220)\left(\frac{220}{110}\right)\cos 0 = 220$ Watt.
nett heat produced $= \langle P \rangle (420 \text{ sec}) = 220(420)$
$= 92400$ Joule
$\approx \frac{92400}{4.2}$ cal $= 22000$ cal

Q17(c) In this case rms value should be equal to 4 A

$$i_{rms} = \frac{i_0}{\sqrt{2}} = 4 \Rightarrow i_0 = 4\sqrt{2} = 5.6\ A$$

Q 18 (a) $\langle P \rangle = V_{rms}\, i_{rms} \cos 90°$

$$= \frac{5}{\sqrt{2}} \cdot \frac{2}{\sqrt{2}} \cos 90° = 0$$

Q 19 (c) $I = I_1 \cos\omega t + I_2 \sin\omega t = \sqrt{I_1^2 + I_2^2}\left[\frac{I_1}{\sqrt{I_1^2+I_2^2}}\cos\omega t + \frac{I_2}{\sqrt{I_1^2+I_2^2}}\sin\omega t\right]$

$$= \sqrt{I_1^2+I_2^2}\,\sin(\omega t+\phi)$$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \sqrt{\frac{I_1^2+I_2^2}{2}}$$

Q 20 (c) $I_0 = I_{rms}\sqrt{2} = 220\sqrt{2}$ Volt

Q 21 (b) Time taken is $\frac{T}{4} = \frac{1}{4}\left(\frac{1}{50}\right) = \frac{1}{200} = 0.005$ sec

Q 22 (c) rms value $= \frac{V_0}{\sqrt{2}} = \frac{707}{1.414} = 500$ V.

Q 23 (d) it measures both a.c. and d.c.

Q 24 (a) $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

$$i_{max} = \frac{V_0}{X_C} = \frac{200\sqrt{2}}{(1/2\pi f C)} = (200\sqrt{2})\, 2\pi f C$$

$$= 200 \times (1.414)\, 2(3.14)\, 50\, (10^{-5})$$

$$= .063\sqrt{2}\ \text{Amp}$$

Q 25 (a) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{5\sqrt{2}}{\sqrt{2}} = 5\ A$

Q 26 (a) Time taken $t = \frac{T}{4} = \frac{1}{4}\left(\frac{1}{100}\right) = \frac{1}{400}$ Sec

{because frequency is $f = 100$}

Q 27 (a) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{120}{\sqrt{2}} = 84.9$ Volt.

Q 28 (b) $\langle P \rangle = \frac{1}{2} e_0 i_0 \cos\phi = \frac{1}{2}(200)(2)\cos\frac{\pi}{3}$

$$= 100\ \text{Watt}$$

AC circuits

Q 1 (c) $X_c = \frac{1}{\omega C} = \frac{1}{100(10^{-6})} = 10^4\,\Omega$

$$i_{rms} = \frac{V_{rms}}{X_c} = \frac{200}{10^4} = 20\ mA$$

Q 2 (a) $\tan\phi = \frac{X_L}{R} = \frac{3}{3} = 1 \Rightarrow \phi = \frac{\pi}{4}$

Q 3 (a) $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 3.536\ A$

Time taken $T = \frac{1}{4}\,\frac{1}{60} = \frac{1}{240}$ sec $= 4.167$ sec

Q 4 (a), (d) At resonance $X_L = X_C$ So $Z = R$

So $I_m = \frac{V_m}{Z} = \frac{V_m}{R}$

5(b) see theory

6 (b) we can check dimensionally or see the conventional proof.

7(c) Transformer works on the principle of mutual induction is a known theoretical fact (see theory)

8(d) Impedance $Z = \sqrt{R^2+(X_L-X_c)^2} = \sqrt{300^2+(\omega L - \frac{1}{\omega C})^2}$ $\{\omega = 2\pi f = 100\text{ Hz}\}$

$= \sqrt{300^2+(100-500)^2}$

$= 500\,\Omega$

9(c) current is same throughout the circuit, in inductance current lags behind by $\frac{\pi}{2}$ and in capacitance current leads by $\frac{\pi}{2}$

10(b) $\cos\phi = \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{1}{\sqrt{2}} \Rightarrow \frac{R^2}{R^2+\omega^2L^2} = \frac{1}{2} \Rightarrow 2R^2 = R^2+\omega^2L^2 \Rightarrow R = \omega L$

when frequency is doubled

$\cos\phi' = \frac{R}{\sqrt{R^2+4\omega^2L^2}} = \frac{R}{\sqrt{5R^2}} = \frac{1}{\sqrt{5}}$

11(d) Since $X_L = X_c \Rightarrow$ Voltmeter reading will be zero and the circuit will be purely resistive

now current $i = \frac{V}{R} = \frac{240}{30} = 8A.$

12(a) $X_L = \frac{100}{8} = 2\pi f L = 2\pi(50)L \Rightarrow L = \frac{1}{8\pi}$ Henry

$R = \frac{100}{10} = 10\,\Omega$

now current in new situation $i = \frac{V}{Z} = \frac{150}{\sqrt{10^2+\left(2\pi(40)\frac{1}{8\pi}\right)^2}}$

$= \frac{150}{10\sqrt{2}} = \frac{15}{\sqrt{2}}$ A

13(c) $\langle P\rangle = \frac{1}{2}V_0 i_0\cos\phi$

$= \frac{1}{2}(100)\frac{(100)}{1000}\cos\frac{\pi}{3} = 2.5$ Watt

14(b) Inductive and capacitive reactance must be same since current and voltage are in same phase.

So $X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow L = \frac{1}{\omega^2 C} = \frac{1}{4\pi^2 f^2 C}$

$= \frac{1}{4(3.14)^2\, 50^2(20\times10^{-6})}$

$L = 0.51$ H

15(c) $Z = \sqrt{R^2+\omega^2L^2} = \sqrt{R^2+4\pi^2f^2L^2}$

16(a) Phase difference $\phi = \cos^{-1}\frac{R}{Z} = \cos^{-1}\frac{10}{10} = \cos^{-1}1 = 0°$

17(b) $i = i_0\left(1-e^{-\frac{Rt}{L}}\right) = i_0\left(1-e^{-\frac{t}{\tau}}\right)$ so $\tau = \frac{L}{R}$

18(b) Since the inductive and capacitive reactance cancel each other the nett impedance is equal to nett resistance i.e. $100\,\Omega$

19(a) The voltmeter connected across the combination of inductance and capacitance reads zero because the circuit is in resonance.

20(b) Both assertion and reason are true but reason is not the correct explanation of assertion.

21(b) $\langle P \rangle = \frac{1}{2} V_0 i_0 \cos\phi$

$= \frac{1}{2}(100)(100)\cos\frac{\pi}{3} = 2500 \text{ Watt} = 2.5 \text{ KW}$

22(b) from the question it is clear that $\phi = 45°$

$\tan\phi = \frac{\omega L}{R} \Rightarrow 1 = \frac{2\pi f L}{R} \Rightarrow 1 = \frac{2\pi(1000)L}{100}$

$\Rightarrow L = \frac{1}{20\pi}$ Henry

23(c) $i_0 = \frac{V_0}{X_L} = \frac{220\sqrt{2}}{2\pi f L} = \frac{220\sqrt{2}}{2(3.14)(50)(1)} \approx 1$ Amp

24(b) read therry

25(a) In resonating circuit $X_L = X_C \Rightarrow 2\pi f L = 6$

$\Rightarrow 2(3)(100)L = 6$

$\Rightarrow L = 0.1$ Henry

26(a) According to energy conservation

$\frac{1}{2}CV^2 = \frac{1}{2}Li^2 \Rightarrow i_{max} = V\sqrt{\frac{C}{L}} = 1\sqrt{\frac{10^{-6}}{10^{-3}}}$

$= \frac{1}{\sqrt{1000}}$ A

$= \sqrt{1000}$ mA

27(a) Since the capacitive reactance $X_C = \frac{1}{\omega L}$ decreases with increase in frequency so the capacitive reactance decreases with ω, as the reactance decreases impedence decreases hence the brightness of lamp increases.

28(d) $Z = \sqrt{R^2 + (2\pi f L)^2} = \sqrt{30^2 + [2\pi(\frac{.4}{\pi})(50)]^2} = \sqrt{30^2 + 40^2} = 50\Omega$

current $i = \frac{200}{50} = 4$ A

29(b) $Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2} = \sqrt{3^2 + (8-4)^2} = 5\Omega$

$i_0 = \frac{V_0}{Z} = \frac{300}{5} = 60$ Amp.

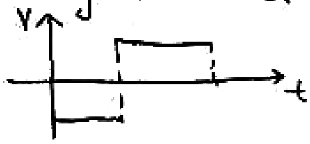
30(d) If the circuit remains incomplete after battery is removed then the charge on capacitor will remain constant, but if the battery is removed and the circuit is joined then both current and charge oscillate simultaniously.

31(d) $\langle P \rangle = V_{rms}\, i_{rms} \cos\phi$

so it depends on V_{rms}, i_{rms} and ϕ.

32 $e = -L\frac{di}{dt} = -L$ (slope of $i-t$ graph)

slope of $i-t$ graph is initially +ve and then −ve so the actual answer is



33(b) L_1 and are in parallel so p.d. across L_1 and L_2 are same

i.e. $L_1\frac{di_1}{dt} = L_2\frac{di_2}{dt} \Rightarrow L_1 i_1 = L_2 i_2$

so $\frac{i_1}{i_2} = \frac{L_2}{L_1}$

34(a) $\langle P \rangle = V_{rms}\, i_{rms} \cos\phi$

$= e \cdot \frac{e}{Z} \cdot \frac{R}{Z} = \frac{e^2 R}{Z^2} = \frac{e^2 R}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$

35(b) current always lags in inductor by phase difference of $\frac{\pi}{2}$

36(c) Inductive reactance $X_L = \omega L = 7\times10^4 (100\times10^{-6}) = 7\,\Omega$

Capacitive reactance $X_C = \frac{1}{\omega C} = \frac{1}{7\times10^4(10^{-6})} = \frac{100}{7} \approx 14.2\,\Omega$

since $X_C > X_L$

so the nett effect is series R-C circuit.

37(b) $\langle P \rangle = V_{rms}\, i_{rms} \cos 90 = 0$

38(a) current always lags behind in an inductor by $\frac{\pi}{2}$

39(c) $i_{max} = i_{rms}\sqrt{2} = 10\sqrt{2}$ Amp.

$V_{max} = i_{max} R = (10\sqrt{2})12 = 169.68$ Volt

40(b) see question 38.

41(b) At resonance $\omega L - \frac{1}{\omega C} = 0$

so $Z = R$, hence the applied voltage is completely across resistance

42 P.D. between V and I is 180°, no option is correct.

43(b) Average power dissipated in a cycle for inductor is zero, so there is no loss of energy, although voltage is distributed.

44(a) $V_{supply} = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{40^2 + (60-30)^2} = 50$ Volt

45(d) Time period of L-C oscillatory circuit is $T = \frac{2\pi}{\omega} = 2\pi\sqrt{LC}$

46 (b) $i_{rms} = \frac{V_{rms}}{X_c} = \frac{200}{(\cancel{100})(\cancel{10^{-6}})} = \frac{200}{\left(\frac{1}{100\times10^{-6}}\right)} = \frac{200}{10^4} = .02A = 20\,mA$

47 (b) $\langle P\rangle = V_{rms}\, i_{rms} \cos 0$

$550 = (220)\, i_{rms} \Rightarrow i_{rms} = 2.5\,A$

48 (a) $V_{max} = V_{rms}\sqrt{2} = 220\sqrt{2}$ Volt

$\omega = 2\pi f = 2\pi(50) = 100\pi$

$e = 220\sqrt{2}\sin(100\pi t)$

49 (a) Applied voltage $V = \sqrt{5^2+12^2} = 13$ Volt

50 (c) $\langle P\rangle = 0$ when $\phi = 90°$

this happen only when circuit is eith purely inductive or capacitive

51 (d) reactance of inductor increases with frequency reactance of capacitor decreases with increase in frequency.

So option d is correct.

52 (a) $I = \frac{V}{\sqrt{R^2+\frac{1}{\omega^2C^2}}}$ — ① also $\frac{I}{2} = \frac{V}{\sqrt{R^2+\frac{9}{\omega^2C^2}}}$ — ②

Dividing ① by ②

$$\frac{I}{(I/2)} = \frac{V\Big/\sqrt{R^2+\frac{1}{\omega^2C^2}}}{V\Big/\sqrt{R^2+\frac{9}{\omega^2C^2}}} \Rightarrow 2 = \frac{\sqrt{R^2+\frac{9}{\omega^2C^2}}}{\sqrt{R^2+\frac{1}{\omega^2C^2}}}$$

$$\Rightarrow 4 = \frac{R^2+\frac{9}{\omega^2C^2}}{R^2+\frac{1}{\omega^2C^2}} \Rightarrow 4R^2+\frac{4}{\omega^2C^2} = R^2+\frac{9}{\omega^2C^2}$$

$$\Rightarrow 3R^2 = 5X_C^2$$

$$\frac{X_C}{R} = \sqrt{\frac{3}{5}}$$

53 (a) current is maximum when circuit is in resonance

i.e. $\omega^2 = \frac{1}{LC} \Rightarrow 10^6 = \frac{1}{L(10^{-5})} \Rightarrow L = 0.1\,H$

$= 100\,mH$

54 (c) when $\omega > \frac{1}{\sqrt{LC}}$ circuit is dominated by inductive reactance

55 (b) $X_L = \omega L = 2\pi f L = 2(3.14)(50)(.7) = 220\,\Omega$

current $i = \frac{220}{\sqrt{220^2+220^2}} = \frac{1}{\sqrt{2}}$ Amp.

wattless component $= \frac{1}{\sqrt{2}}\sin 45 = 0.5$ Amp

56 (c) In a resonant circuit $X_L = X_C$ and there is no phase difference between V & i, so $\cos\phi = 1$ $(\phi = 0)$

57 (a) $Z = \sqrt{R^2+\left(\frac{1}{\omega C}\right)^2} = \sqrt{100^2+\left(\frac{1}{100(20\times10^{-6})}\right)^2} = 100\sqrt{26}$

$\approx 510\,\Omega$

58(c) $E = \sqrt{V_R^2+(V_L-V_c)^2} = \sqrt{80^2+(40-160)^2}$
$= \sqrt{80^2+60^2} = 100$ Volt

59(d) The factor which is true is statement (d) see theory.

60(a) Since $V_L = V_C \Rightarrow V = 200$ Volt {circuit is in resonance}
$i = \frac{V}{R} = \frac{200}{100} = 2$ Amp.

61(b) Quality factor $Q = \frac{\omega L}{R} = \frac{1}{\sqrt{LC}}\frac{L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$

62(b) power factor $\cos\phi = \frac{R}{Z}$ and when $Z = R$
power factor is unity

63(a) $\tan\phi = \frac{X_L}{R} = \tan 45 = 1 \Rightarrow X_L = R$

64(c) $f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$ and $f' = \frac{1}{2\pi}\frac{1}{\sqrt{2L(4C)}}$
now $\frac{f'}{f} = \frac{1}{2\sqrt{2}} \Rightarrow f' = \frac{f}{2\sqrt{2}}$

65(b) Q factor $= \frac{2\pi f L}{R} = \frac{2(3.14)(500)(8.1\times10^{-3})}{1000} = 2.54$

66(a) we are expected to learn this formula (see theory)

67(d) Any L-C-R series circuit is in resonance when $X_L = X_C$ or $X_L - X_C = 0$

68(a) In 1st ckt $i_1 = 0$ just after switch is closed (initially inductor behaves as open ckt)
In 2nd ckt $i_2 = \frac{V}{R}$
In 3rd ckt $i_3 = \frac{V}{2R}$ so $i_2 > i_3 > i_1$

69(b) Power dissipated $\langle P\rangle = V_{rms} i_{rms} \cos\phi$
$= V \frac{V}{\sqrt{R^2+\omega^2L^2}} \cdot \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{V^2R}{R^2+\omega^2L^2}$

70(b) $\tan\phi = \frac{X_L}{R} = \tan 45 = 1$
$\Rightarrow X_L = R \Rightarrow 2\pi f L = 100$
$\Rightarrow L = \frac{100}{2\pi(1000)} = \frac{1}{20}$ Henry

71(a) $X_L = 2\pi f L = 50\,\Omega$
$L = \frac{50}{2(3.14)(50)} = 0.16$ Henry

72(d) $V_{source}^2 = V_R^2 + V_L^2 \Rightarrow 200^2 = 100^2 + V_L^2 \Rightarrow V_L = 100\sqrt{3}$
$\langle P\rangle = V i = 100 i = 50$
$\Rightarrow i = 0.5$ Amp

$V_L = i X_L = i(2\pi f L)$
$100\sqrt{3} = \frac{1}{2}(2\pi)(50)L \Rightarrow L = \frac{2\sqrt{3}}{\pi} = 1.1$ H

73(b) $\phi = \tan^{-1}\frac{X_L \sim X_C}{R} = \tan^{-1}\frac{2\pi f L - \frac{1}{2\pi f C}}{R}$

$= \tan^{-1}\left(\frac{\frac{2\pi(50)200}{1000\pi} - \frac{\pi}{2\pi(50)10^{-3}}}{10}\right)$

$= \tan^{-1}\left(\frac{20-10}{10}\right) = \tan^{-1}1 = \frac{\pi}{4}$

74(d) Circuit is inductive because in inductive circuit current lags behind by 90°

75(c) power factor $\cos\phi = \frac{R}{Z} = \frac{8}{\sqrt{8^2+(31-25)^2}} = \frac{8}{10} = 0.8$

76(b) X_L has to be much greater then R otherwise there will be excessive heat loss from the choke coil itself.

77(c) At resonance power factor is always zero

78(a) $\cos\phi = \frac{R}{\sqrt{R^2+(X_L-X_C)^2}}$; at resonance $X_L = X_C$

so $\cos\phi = 1$

79(d) $f_0 = \frac{1}{2\pi\sqrt{LC}}$, let the new frequency after capacitance become 4 times

$f = \frac{1}{2\pi\sqrt{L4C}} \Rightarrow \frac{f}{f_0} = \frac{1}{2} \Rightarrow f = \frac{f_0}{2}$

80(a) $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-2}(.25\times10^{-6})}} = 2\times10^4$

$f = \frac{\omega}{2\pi} = \frac{1}{\pi}\times10^4$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{\frac{1}{\pi}\times10^4} = 9.42\times10^4\ m$

81(a) $Z = \sqrt{R^2+(X_L-X_C)^2} = \sqrt{3^2+(15-11)^2} = 5\Omega$

$i = \frac{V}{Z} = \frac{10}{5} = 2$ Amp.

P.D. across series combination of X_L and $X_C = i(X_L - X_C) = 8$ Volt

82(d) applying energy conservation $\frac{1}{2}CV^2 = \frac{1}{2}Li^2 \Rightarrow i_{max} = V\sqrt{\frac{C}{L}}$

$= 20\sqrt{\frac{16\times10^{-6}}{40\times10^{-3}}}$

$= 20(2\times10^{-2})$

$= 0.4$ Amp

83(a) $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2(3.14)\sqrt{10^{-7}\times0.25}} \simeq 1007\ Hz$

84(a) since the current is lagging behind the components in the ckt are L and R

85 (a) $\frac{X_L}{X_C} = \frac{\omega L}{1/\omega C} = \omega^2 LC$

86 (a) $\tan\phi = \frac{X_L}{R} = \frac{2\pi f L}{R} = \frac{2\pi(50)(.01)}{1} = \pi$

$\phi = \tan^{-1}\pi$

87 (c) $\cos\phi = \frac{R}{\sqrt{R^2+(2\pi f L)^2}} = 0.6$

$\Rightarrow R^2 = 0.36(R^2+\omega^2L^2) = 0.36R^2 + 0.36\omega^2L^2$

$\Rightarrow 0.64R^2 = 0.36\omega^2L^2$

$\Rightarrow 0.8R = 0.6\omega L \Rightarrow \omega L = \frac{4}{3}R$

power factor is 1 when $\omega L = \frac{1}{\omega C}$ so $\frac{1}{\omega C} = \frac{4}{3}R$

$\langle P \rangle = V_{rms} \cdot \frac{V_{rms}}{Z}\cos\phi \Rightarrow 330 = \frac{(110)^2}{\sqrt{R^2+X_L^2}}(.6)$

$\Rightarrow R^2 + X_L^2 = 484$

now $X_L = \frac{4}{3}R$ so $R^2 + \frac{16}{9}R^2 = 484 \Rightarrow \frac{25}{9}R^2 = 484$

$\Rightarrow R = \frac{66}{5}\Omega$

So $\frac{1}{\omega C} = \frac{4}{3}\frac{66}{5} = \frac{264}{15}$

$\Rightarrow C = \frac{15}{264}\frac{1}{(2\times3.14\times60)} = 151\mu F$

88 (d) $X_L = 2\pi f L = 2\pi\left(\frac{50}{\pi}\right)1 = 100\Omega$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi\left(\frac{50}{\pi}\right)(2\times10^{-5})} = 500\Omega$

$Z = \sqrt{R^2+(X_L\sim X_C)^2} = \sqrt{300^2+(100-500)^2} = 500\Omega$

current $i = \frac{V}{Z} = \frac{50}{500} = 0.1$ Amp

P.D. across capacitor $= iX_C = (0.1)(500) = 50$ Volt

89 (d) current always lags by $\frac{\pi}{2}$ in pure inductive circuit.

90 (a) $\tan\phi = \frac{X_C - X_L}{R} = \tan 45 \Rightarrow X_C - X_L = R$

$\Rightarrow \frac{1}{\omega C} = R + 2\pi f L$

$\Rightarrow C = \frac{1}{2\pi f(R+2\pi f L)}$

91 (b) when $X_L = X_C$ Nett impedance $Z = \sqrt{R^2+(X_L-X_C)^2} = R = 25\Omega$

92 (d) for the circuit to be in resonance ω should remain unchanged $\omega = \frac{1}{\sqrt{LC}}$ so when C is made $\frac{1}{4}$th, L must become 4 times.

93 (b) $\frac{\omega L}{R} = 0.4$ ~~or~~ also ~~Q~~ $= \frac{260}{\omega} = \frac{1300}{\omega} = 0.4 \Rightarrow \omega = \frac{1300}{0.4} = 3250$ Hz

$\omega^2 = \frac{1}{LC} \Rightarrow L = \frac{1}{\omega^2 C} = \frac{10^7}{(3250)^2(10^{-7})} = 0.94 H$

94(b) $(2\pi f)^2 = \frac{1}{LC} \Rightarrow L = \frac{1}{4\pi^2 f^2 C}$

$= \frac{1}{4(3.14)^2(10^6)^2(3\times10^{-10})} = 84.4\ H$

95(b) $\omega = \frac{1}{\sqrt{LC}}$, in order to mentain the same frequency, if capacitance is doubled inductance should be halved

96 (b) Read theory

97 (b) $V_c = V_L = 50\ V$, V_c and V_L are 180° out of phase, so they cancel each other, so voltage across L-C combination is zero.

98 (b) for pure inductor current lags behind by 90°

99 (c) $X_c = \frac{1}{2\pi f C} \Rightarrow$ graph between X_c and f will be hyperbola.

$X_L = 2\pi f L \Rightarrow$ graph will be straight line

so graph ① is for capacitor, ② is for inductor

100(d) after the battery is removed, circuit becomes L-C oscillatory circuit in which both current and charge oscillate with angular frequency $\omega = \frac{1}{\sqrt{LC}}$.

101 $\cos\phi = \frac{R}{Z} = \frac{1}{\sqrt{3}} \Rightarrow \phi = \cos^{-1}\frac{1}{\sqrt{3}}$

GROWTH AND DECAY OF CURRENT

1(a) Finally the inductance behaves as an ideal wire, so current will be $i = \frac{E}{R}$

2(d) Initially capacitor behaves as short circuit and finally as open circuit, so $i_{in} = \frac{2}{1000} = 2mA$, $i_{final} = \frac{2}{2000} = 1mA$ } current reduces to 1mA from 2mA in time t

3 $i = i_0(1 - e^{-\frac{Rt}{L}}) \Rightarrow \frac{i_0}{2} = i_0(1 - e^{-\frac{Rt}{L}})$

$\Rightarrow e^{\frac{Rt}{L}} = 2 \Rightarrow \frac{Rt}{L} = \ln 2$

$\Rightarrow t = \frac{L}{R}\ln 2 = \frac{0.3}{2}(.7)$

$\approx 0.1\ sec$

4(c) $\tau = \frac{L}{R} = \frac{40}{8} = 5$ sec

5(a) $i = i_0\left(1 - e^{-\frac{t}{\tau}}\right)$

put $t = \tau$

$i = i_0\left(1 - \frac{1}{e}\right) = i_0(1 - .37)$

$= .63\, i_0$

6(c) In resonating circuit $X_L = X_C = \frac{1}{\omega C} = \frac{1}{200(2\times10^{-6})} = 2.5\times10^{3}\,\Omega$

now current in circuit

$i = \frac{V}{R} = \frac{100}{1000} = 0.1$ Amp.

Voltage across $L \Rightarrow$ $V_L = i X_L = (0.1)(2500)$

$= 250$ Volt