Q1

1.1 D . 4'

1.2 . Y → Δ change .

$Z_1 = \frac{1}{j\omega 6}$

$Z_2 = 3Z_1 \Rightarrow Z_2 = \frac{1}{j\omega \frac{C}{3}}$ 2'

$\Rightarrow C = \frac{6}{3} = \frac{100}{3}\mu F$. 2'

1.3 $\frac{I_1}{I_2} = \frac{V_2}{V_1} = \frac{220}{1100}$ 1'

$I_1 = 10A$

$\Rightarrow I_2 = 50A$ 3'

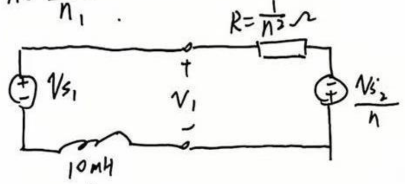
1.4 C 2' .

reasoning : 4'

(reasonable ones would be ok).

eg. use circuit transformation :

$n = \frac{n_2}{n_1}$.



$\downarrow$

$j\omega L = j$ let $V_{s2} = V_{s1} = V$.

$$I = \frac{V_{s1} + \frac{V_{s2}}{n}}{\frac{1}{n^2} + j} = \frac{(n^2+n)V(1-n^2 j)}{1+n^4}$$

$$P = I^2 R = \left[\frac{(n^2+n)V}{1+n^4}\right]^2 (1+n^4) \cdot \frac{1}{n^2} = \frac{(n+1)^2}{1+n^4}V^2$$

$$\frac{dP}{dn} = \frac{2(n+1)(1+n^4) - 4n^3(n+1)^2}{(1+n^4)^2} \quad \frac{dP}{dn} = 0$$

$\Rightarrow n = 0.7167$ $\frac{n_2}{n_1} < 1 \Rightarrow n_2 < n_1$

1.5 6'

(reasonable provement would be ok)

eg. Let $V_i = V_m \cos\omega t = V_m \angle 0°$

$\underline{Z_C = \frac{1}{j\omega C}}$

$$I = \frac{V_i}{R + Z_C} = \frac{V_m}{R + \frac{1}{j\omega C}} = \frac{V_m \cdot j\omega C}{jR\omega C + 1}$$

$$\underline{V_o = I Z_C = \frac{V_m}{jR\omega C + 1}}$$

$$= \frac{V_m(-jR\omega C + 1)}{(jR\omega C + 1)(1 - j\omega RC)}$$

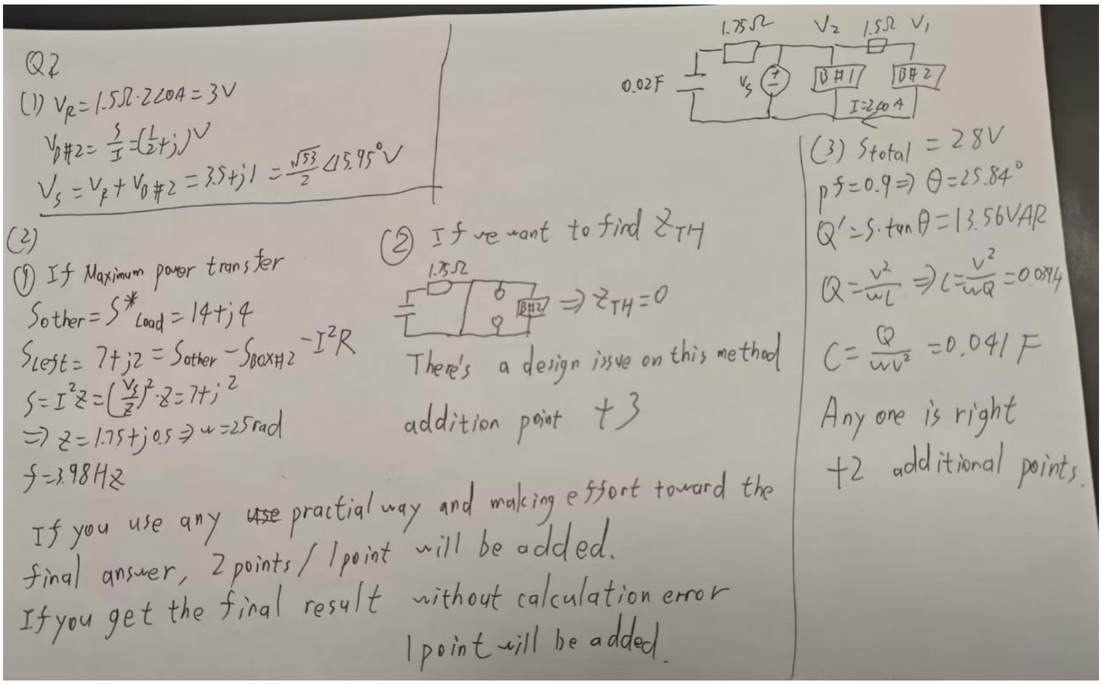
$$= \frac{V_m}{1 + R^2\omega^2 C^2}(1 - jR\omega C)$$

$Arg(1 - jR\omega C) = -90° \Rightarrow \underline{\omega = \infty \, rad \cdot s^{-1}}$

it is not achievable .

$$|V_o| = \frac{|V_m|}{|j\omega RC + 1|} = 0$$

Q2



Q2

(1) $V_R = 1.5\Omega \cdot 2\angle 0 A = 3V$

$V_{B\#2} = \frac{S}{I} = (\frac{1}{2}+j)V$

$V_s = V_R + V_{B\#2} = 3.5+j1 = \frac{\sqrt{53}}{2}\angle 15.95^\circ V$

(2)

① If Maximum power transfer

$S_{other} = S^*_{Load} = 14+j4$

$S_{Left} = 7+j2 = S_{other} - S_{BOX\#2} - I^2R$

$S = I^2 Z = (\frac{V_s}{Z})^2 \cdot Z = 7+j2$

$\Rightarrow Z = 1.75+j0.5 \Rightarrow \omega = 25 rad$

$f = 3.98 Hz$

② If we want to find Z_{TH}

$\Rightarrow Z_{TH} = 0$

There's a design issue on this method

addition point +3

If you use any ~~use~~ practial way and making effort toward the final answer, 2 points / 1 point will be added.

If you get the final result without calculation error 1 point will be added.

(3) $S_{total} = 28V$

$pf = 0.9 \Rightarrow \theta = 25.84^\circ$

$Q' = S \cdot \tan\theta = 13.56 VAR$

$Q = \frac{V^2}{\omega L} \Rightarrow C = \frac{V^2}{\omega Q} = 0.0894$

$C = \frac{Q}{\omega V^2} = 0.041 F$

Any one is right

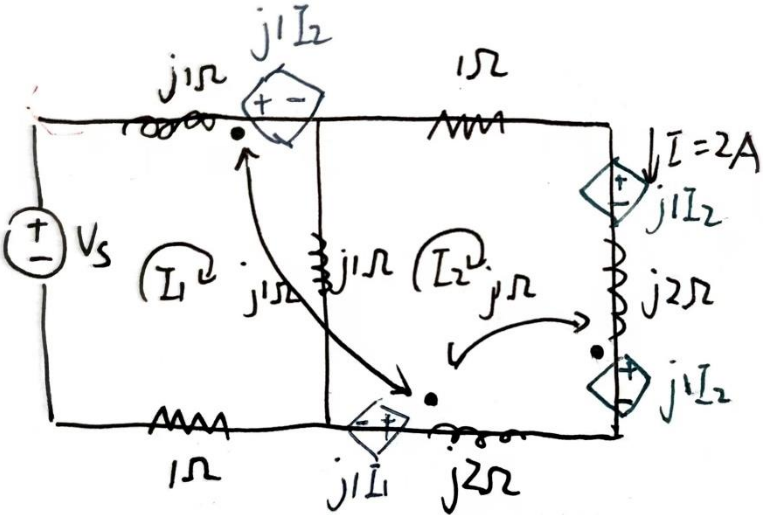
+2 additional points.

Above is the intended solution of the Question 2 and its design. It is solvable by the process above, but at the same time we encountered that the question has the design issue: If we use Thevenin equivalent model, the question is not solvable, meaning that there is the design issue.

We marked your answer **(a)** as above. However, **for (b) and (c)**, we **first** provided **full credits**. And, we took into your detailed answers and gave **additional points on your approach/conceptual thought**.

Q3

(a) The diagram for part (a) is shown below:



(b) For part (b), the simplified equations are as follows:

$$\begin{cases} V_s = (2j+1)I_1, \\ (7j+1)I_2 = 0. \end{cases}$$

From the second equation, we get I_2 = 0. However, this contradicts the conditions stated in the problem.

Rubrics:

Case 1. No modification and derived right KVL. **Full marks**.

Case 2. Modification and derived right KVL. We checked your **consistency** of the answer in (a) and (b). e.g. If you modified (a) part due to the contradiction, and KVL is derived in a right way. **Full marks.**

Case of deductions:

Case 1. No modification with wrong answer in (a). 2 points were deducted for each incorrect voltage source (including direction and magnitude). If the answer includes ω, each will only get 1 point.

Case 2. For (b), if KVL is not used, 0 points will be awarded.

Case 3. For (b), if KVL equations do not match the diagram in (a), 3 points will be deducted for each incorrect equation.

Full marks for (c).

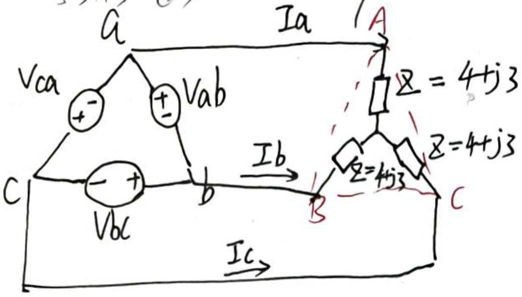
Q4

Q3. $-66.87 \Rightarrow 293.13$

$-186.87 \Rightarrow 173.13$

-306.87

(a) $53.13 \Rightarrow$



$$\Rightarrow \begin{cases} V_{AB} = V_{ab} = 8.66\angle 0^\circ\ V \\ V_{CA} = V_{ca} = 8.66\angle 120^\circ\ V \\ V_{BC} = V_{bc} = 8.66\angle -120^\circ\ V \end{cases} \quad 3'$$

$$\Rightarrow \begin{cases} I_a = 1.00\angle -66.87^\circ\ A \\ I_b = 1.00\angle -186.87^\circ\ A \\ I_c = 1.00\angle 53.13^\circ\ A \end{cases} \quad 3'$$

Δ-Y: $V_L = V_P \Rightarrow \hat{V}_{AB} = \hat{V}_{ab}$

$\hat{V}_{ab} = 8.66\angle 0^\circ$

$\hat{V}_{bc} = 8.66\angle -120^\circ$

$\hat{V}_{ca} = 8.66\angle +120^\circ$

Replace the Y-connected load with its equivalent Δ-connected load and recall that for a Δ-connected load,

$\hat{I}_a = \hat{I}_{AB}\sqrt{3}\angle -30^\circ = \dfrac{\hat{V}_{AB}}{Z_\Delta}\sqrt{3}\angle -30^\circ$

$Z_\Delta = 3Z_Y = 12 + 9j\ (\Omega)$

$\hat{I}_b = \hat{I}_a\angle -120^\circ = \dfrac{\hat{V}_{AB}}{Z_\Delta}\sqrt{3}\angle -150^\circ$

$\hat{I}_c = \hat{I}_a\angle +120^\circ = \dfrac{\hat{V}_{AB}}{Z_\Delta}\sqrt{3}\angle 90^\circ$

Q(a) full mark is assigned if results are correct.

Otherwise, $Z_\Delta = 3Z_Y$ 1', or the calculation for $\hat{I}_a$, $\hat{I}_b$, $\hat{I}_c$ each earns 1' $\boxed{1' \text{ maximum}}$

(b) $S_{per\text{-}phase} = V_{rms} I^*_{rms\text{-}\Delta} = V_{p\_load} I^*_{p\_load} = 5\angle 36.87\ [VA]$ or: $4+3j$.

$S_{total} = 3S_{per\text{-}phase} = 15\angle 36.87^\circ\ [VA]$ +2

(or $12 + 9j$)

(c) $\theta = 36.87^\circ$

$pf = \cos\theta = \underset{+1}{\underline{0.8}}$ $\underset{+2}{\underline{\text{lagging}}}$

If this is wrong 3' is deducted.

Q(b): process points: $V_{rms} I^*_{rms}$ 1'

$S_{total} = 3S_{per}$

or $S_{total} = 3V_p I_p \cos\theta$ 1'

Q(c): no process point. $\boxed{1' \text{ maximum}}$

Rubrics

(a) $V_L = V_P$ of the source, and followed this to calculate three line sources -----3point

Then , calculate I_a, I_b, I_c ----3points

The full marks were given as long as the result (= **value+unit**) is correct. If one or more unit is missing or wrong, 1 point is deducted (did not deduct repeatedly).
If the result is wrong, a maximum 1 point for process can be assigned, as long as an equation for calculating I, V, Z is shown correctly.

(b)

$$Sphase = V_p load * (I_p load)^* = 4 + 3j[VA]$$ ----2point

$$Stotal = 3 * Sphase = 12 + 9j[VA]$$ ----1point

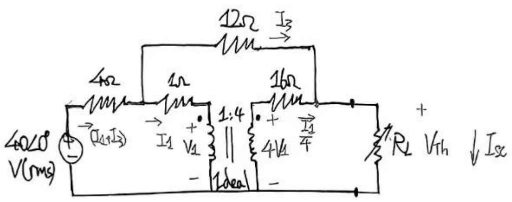
The full marks was given as long as the result (= **value+unit**) is correct. If one or more unit is missing or wrong, 1 point is deducted (did not deduct repeatedly).
If the result is wrong, a maximum1 point for process can be assigned, as long as an equation such as $S_{total} = 3S_{per\_phase}$ is shown correctly.

(c)

No process point is assigned for this sub-question, pf = cos(36.87) = 0.8 ---- 1point
lagging----2 point

Q5

Q5.



(a) Open circuit voltage:

$$\begin{cases} 40\angle 0^\circ = 4(I_1+I_3) + 12I_3 + V_{Th} & 1' \\ \frac{I_1}{4} = -I_3 & 1' \end{cases}$$

$\Rightarrow V_{Th} = 40\angle 0^\circ \quad 2'$

Short circuit current:

$$\begin{cases} 40\angle 0^\circ = 4(I_1+I_3) + I_1 + V_1 & 1' \\ 4V_1 = 16 \cdot \frac{I_1}{4} & 1' \\ 40\angle 0^\circ = 4(I_1+I_3) + 12I_3 & 1' \end{cases}$$

$\Rightarrow I_1 = 6A \quad 1' \quad I_3 = 1A \quad 1'$

$I_{sc} = \frac{I_1}{4} + I_3 = 2.5A \quad 1'$

(b) $R_{Th} = \frac{V_{Th}}{I_{sc}} = 16\Omega \quad 2'$

(c) When $R_L = R_{Th} = 16\Omega \quad 2'$

$P_{max} = \frac{1}{2} I^2 R_L = \left(\frac{40\angle 0^\circ}{32}\right)^2 \times 16 \times \frac{1}{2} = 12.5W \quad 2'$

* If you calculated as $P_{max} = I^2R$ $-1'$.

maximum avg power refers to the load

(d)

$$\begin{cases} 40\angle 0^\circ = 4(I_1+I_3) + 12I_3 + 20\angle 0^\circ & 1' \\ 4V_1 = 16\Omega \cdot \left(\frac{I_1}{4}\right) + 16\left(\frac{I_1}{4} + I_3\right) & 1' \end{cases}$$

$\Rightarrow I_1 = 6A \; 1' \quad I_3 = -0.25A \; 1' \quad I = I_1 + I_3 = 5.75A$

$P = VI = 40\angle 0^\circ \cdot (6 - 0.25) = 230W \quad 2'$