CLASS TEST

S.No.: 01SKEE_A to Q_30925

MADE EASY

Leading Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune | Kolkata

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

POWER SYSTEM-1

ELECTRICAL ENGINEERING

Date of Test : 30/09/2025

ANSWER KEY

1.	(a)	7.	(a)	13.	(c)	19.	(b)	25.	(b)
2.	(b)	8.	(d)	14.	(c)	20.	(b)	26.	(b)
3.	(d)	9.	(a)	15.	(a)	21.	(a)	27.	(b)
4.	(c)	10.	(b)	16.	(d)	22.	(d)	28.	(b)
5.	(d)	11.	(a)	17.	(b)	23.	(b)	29.	(c)
6.	(b)	12.	(a)	18.	(b)	24.	(c)	30.	(a)

DETAILED EXPLANATIONS

1. **(a)**

$$\text{Average demand} = \frac{\text{Units generated/annum}}{\text{Hours in a year}}$$

$$= \frac{61.5\times10^6}{24\times365} = 7020.54 \text{ kW}$$

$$\text{Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}} = \frac{7020.54}{20\times10^3}\frac{\text{kW}}{\text{kW}}$$

$$\text{Load factor} = 0.35$$

2. **(b)**

No load receiving end voltage,

$$V_R = \frac{V_s}{A}$$

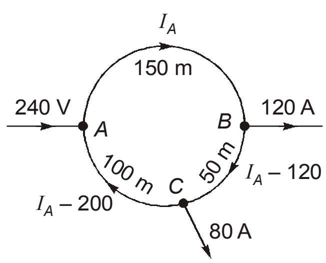
$$V_R = \frac{400}{0.8} = 500 \text{ kV}$$

$$\text{The sending end current} = I_s = CV_R$$

$$= (0.5\times10^{-6})\left(\frac{500 \text{ kV}}{\sqrt{3}}\right) = 0.1443 \text{ A}$$

3. **(d)**

Resistance per 100 m of distributor = 2 × 0.03 = 0.06 Ω



Resistance of AB, $$R_{AB} = (0.06)\left(\frac{150}{100}\right) = 0.09\ \Omega$$

$$R_{BC} = 0.06\times\frac{50}{100} = 0.03\,\Omega$$

$$R_{CA} = 0.06\times\frac{100}{100} = 0.06\,\Omega$$

Applying KVL in the loop:

$$I_{AB}R_{AB} + I_{BC}R_{BC} + I_{CA}R_{CA} = 0$$

$$0.09\,I_{AB} + 0.03\,(I_{AB} - 120) + 0.06\,(I_{AB} - 200) = 0$$

$$0.18\,I_{AB} = 15.6$$

$$I_{AB} = \frac{15.6}{0.18} = 86.67 \text{ A}$$

4. **(c)**

$$\text{String efficiency, } \%\,\eta = \frac{V}{nV_n}\times100$$

Given, $n = 5$,

V_5 = 0.25 V = voltage across the bottom most unit.

$$\%\,\eta = \frac{V}{5\times 0.25V}\times 100$$

$$\%\eta = 80\%$$

5. (d)

$$P_e = \frac{EV}{X}\sin\theta$$

$$\frac{P_1}{P_2} = \left(\frac{V_1}{V_2}\right)^2$$

$$\frac{20}{P_2} = \left(\frac{11}{33}\right)^2$$

$$\therefore \quad P_2 = 180\text{ MW}$$

6. (b)

$$\text{Insulation Resistance} = \frac{\rho}{2\pi l}\ln\left(\frac{R}{r}\right)$$

Thus, $R_i \ \alpha\ \frac{1}{l}$

$$\therefore \quad R_i = \frac{200}{5} = 40\,\text{M}\Omega$$

7. (a)

$$\text{Average load} = \frac{\text{Energy generated in MWh during the day}}{24}$$

$$= \frac{(6\times 40)+(4\times 50)+(2\times 60)+(4\times 50)+(4\times 82)+(4\times 40)}{24}$$

$$\text{Average load} = \frac{1248}{24} = 52\text{ MW}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum demand}} = \frac{52}{82}\times 100 = 63.41\%$$

8. (d)

Zero regulation always at leading power factor load and for zero regulation, we have

$$\phi_R = \theta = \tan^{-1}\left[\frac{X_L}{R}\right]$$

Given : $R = X_L$

Therefore, $\phi_R = \tan^{-1}\left[\frac{X_L}{R}\right] = \tan^{-1} 1 = 45°$

$\therefore \quad \cos\phi_R = \cos 45° = 0.707$ leading

Hence, the load will have 0.707 leading power factor.

9. (a)

$$C_n = 12\ \mu F$$

$$C_n = \frac{12 \mu F}{400\,km} = 0.03\ \mu F/km$$

$$C_n = \frac{2\pi \in}{\ln \frac{D}{r}} = \frac{55.631 \times 10^{-12}}{\ln \frac{D}{r}} F/m = \frac{55.631 \times 10^{-3}}{\ln \frac{D}{r}} \mu F/km$$

$$\Rightarrow \quad \frac{55.631 \times 10^{-3}}{\ln \frac{D}{r}} = 0.03$$

$$\ln \frac{D}{r} = 1.854$$

$$\frac{D}{r} = 6.3877$$

$$r = \frac{1}{6.3877} = 15.65\ cm$$

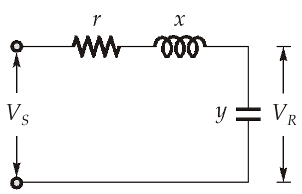
Now, Inductance per phase $= 0.2 \ln \frac{D}{r'} mH/km$

$$= 0.2 \ln \frac{100}{0.7787 \times 15.65} = 0.42\ mH/km$$

10. (b)

In a SF_6 circuit breaker, the SF_6 gas is used at low velocity and low pressure due to which current chopping is prevented and capacitive currents are interrupted without restriking. Due to these reasons no switching resistor is required in these breakers. Hence, it is most suitable for short line fault without switching resistors.

11. (a)



Let length of line be l km,

$$|V_S| = |A||V_R| \qquad \text{When } I_R = 0 \text{ at no load.}$$

$$|A| = \frac{220}{235} = 0.936$$

For receiving end condenser

$$|A| = |1 + YZ|$$

$$Y = j2.8 \times 10^{-6}\ l$$

$$Z = j0.4l$$

$$|A| = |1 + YZ|$$

$$YZ = j0.4l \times j2.8 \times 10^{-6}\ l$$

$$YZ = -1.12 \times 10^{-6}\ l^2$$

$$|A| = |1+YZ| = \left|1-1.12\times10^{-6}l^2\right|$$

$$0.936 = 1 - 1.12 \times 10^{-6}\, l^2$$

$$l^2 = \frac{1-0.936}{1.12\times10^{-6}} = \frac{400000}{7}$$

$$l = 239.04 \text{ km}$$

12. (a)

Since the generators are in parallel, they will operate at the same frequency at steady load.

Let load on generator 1 (200 MW) = x MW

load on generator 2 (400 MW) = $(600 - x)$ MW

and reduction in frequency = Δf

$$\therefore \quad \frac{\Delta f}{x} = \frac{0.04\times50}{200} \quad \text{... (i)}$$

and

$$\frac{\Delta f}{600-x} = \frac{0.05\times50}{400} \quad \text{... (ii)}$$

Equating Δf in (i) and (ii),

$$x = 230.769 \approx 231 \text{ MW (load on generator-1)}$$

$$600 - x = 369 \text{ MW (load on generator-2)}$$

$$\therefore \quad \text{System frequency} = 50-\frac{0.04\times50}{200}\times231 = 47.69 \text{ Hz.}$$

13. (c)

Given, $|V_s| = |V_R| = 275$ kV, $\alpha = 5°, \beta = 75°$

Since the power is received at unity power factor, therefore

$$Q_R = 0$$

Now,
$$Q_R = \frac{|V_s|\,|V_R|}{|B|}\sin(\beta-\delta)-\frac{|A|\,|V_R|^2}{|B|}\sin(\beta-\alpha)$$

or,
$$0 = \frac{275\times275}{200}\sin(75°-\delta)-\frac{0.85}{200}\times275^2\sin(75°-5°)$$

or, $378 \sin(75 - \delta) = 302$

or, $\sin(75 - \delta) = 0.798$

or, $\delta = 22°$

Now,
$$P_R = \frac{|V_s|\,|V_R|}{|B|}\cos(\beta-\delta)-\frac{|A|\,|V_R|^2}{|B|}\cos(\beta-\alpha)$$

$$= \frac{275\times275}{200}\cos(75°-22°)-\frac{0.85\times275^2}{200}\cos70°$$

or, $P_R = 117.63$ MW

14. (c)

$$C = \frac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{R}{r}\right)}\text{ F/m} = \frac{2\pi\times8.854\times10^{-12}\times2.4}{\ln\left(\frac{15}{10}\right)}\text{ F/m}$$

$$= 0.329\ \mu\text{F/km}$$

$\therefore$ Total cable capacitance $= 0.329 \times 2.5$ (Since $l = 2.5$ km)

$= 0.8225\ \mu F$

So, dielectric loss, $P_d = V_{ph}^2 \omega C \tan\delta$

$= (11000)^2 \times (100\ \pi)\ (0.8225 \times 10^{-6})\ (0.031)$

or, $P_d = 969$ W

15. (a)

$$\text{Radius, } r = \frac{1}{2}\times 21\times 10^{-3} = 10.5\times 10^{-3}\,\text{m}$$

$$D_{eq} = (3 \times 5 \times 3.6)^{1/3} \approx 3.78 \text{ m}$$

$$r' = 0.7788\ r = 0.7788 \times 10.5 \times 10^{-3} = 8.177 \times 10^{-3} \text{ m}$$

Inductance per phase,

$$L = 2\times 10^{-7} \ln\frac{D_{eq}}{r} \text{ H/m}$$

$$= 2\times 10^{-7} \ln\frac{3.78}{8.177\times 10^{-3}} = 12.272 \times 10^{-4} \text{ H/km}$$

$\therefore$ Inductive reactance per phase per km is:

$$X_L = 2\pi f L = 2\pi \times 50 \times 12.272 \times 10^{-4} = 0.386\ \Omega/\text{km}$$

16. (d)

Number of units = 3

Voltage across the second unit, $V_2 = 15$ kV

Voltage across the thrid unit, $V_3 = 20$ kV

$$\frac{V_3}{V_2} = \frac{V_1(1+3K+K^2)}{V_1(1+K)}$$

$$\frac{20}{15} = \frac{1+3K+K^2}{1+K}$$

$$20\,K + 20 = 15 + 45\,K + 15\,K^2$$

$$15\,K^2 + 25\,K - 5 = 0$$

$K = 0.18$ by ignoring the negative value.

17. (b)

$$\Delta f = \frac{-\Delta P}{\frac{1}{R_1}+\frac{1}{R_2}+B}$$

On a common base of 1000 MVA

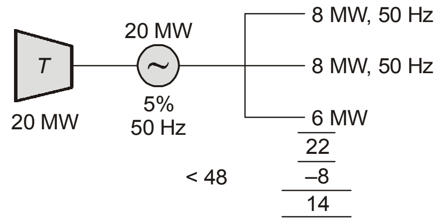
$$R_1 = (0.04)\left(\frac{1000}{400}\right) = 0.1$$

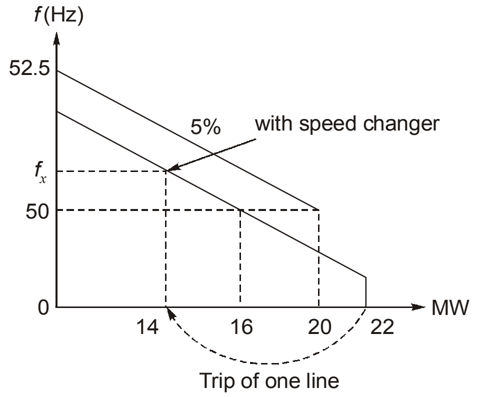
$$R_2 = (0.05)\left(\frac{1000}{800}\right) = 0.0625$$

$$\Delta f = \frac{-130/1000}{\frac{1}{0.1}+\frac{1}{0.0625}} = -5 \times 10^{-3} \text{ p.u.}$$

$$f = f_0 + \Delta f = 50 - (5 \times 10^{-3})\,(50)$$
$$= 49.75 \text{ Hz}$$

18. (b)





From droop characteristic,

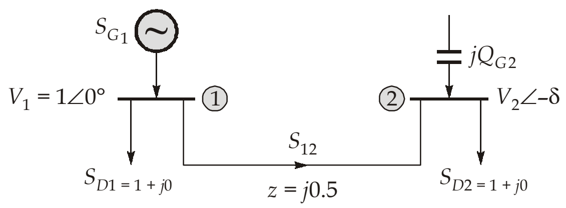
$$\frac{\Delta f_1}{\Delta P_1} = \frac{\Delta f_2}{\Delta P_2}$$

$$\frac{2.5}{20} = \frac{\Delta f_2}{2}$$

$$\Rightarrow \quad \Delta f_2 = 0.25$$

$$f_x = 50 + 0.25 = 50.25 \text{ Hz}$$

19. (b)



$$P_S = \frac{V_1 V_2}{X_L}\sin\delta$$

$$1 = \frac{1 \times 1}{0.5}\sin(0-\delta)$$

$$\delta = -30^\circ$$

$$Q_R = \frac{V_S V_R}{X_L}\cos\delta - \frac{V_R^2}{X_L}$$

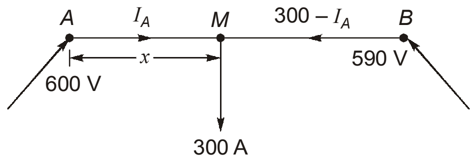
$$= -0.268 \text{ pu}$$

$$Q_C = Q_{G2} = -Q_R = -(-0.268)$$

$$= 0.268 \text{ pu}$$

20. (b)

Let minimum potential occurs at point M at a distance x km from substation A. Let I_A amperes be the current supplied by the substation A. The current supplied by substation B is $300 - I_A$.



Resistance of track per km = $0.04\ \Omega$

Resistance of section AM = $0.04\ x\ \Omega$

Resistance of section MB = $0.04\ (6 - x)\ \Omega$

Potential at M, $V_M = V_A - I_A R_{AM}$ ...(i)

Potential at M, $V_M = V_B - (300 - I_A)\ R_{MB}$ ...(ii)

Equating equations (i) and (ii),

$$V_A - I_A R_{AM} = V_B - (300 - I_A) R_{MB}$$

$$600 - 0.04x\ I_A = 590 - [(300 - I_A) \times 0.04\ (6 - x)]$$

$$I_A = 341.67 - 50x$$

Now substituting the value of I_A in equation (i) we get,

$$V_M = V_A - (341.67 - 50x) \times 0.04x$$

$$V_M = 600 - 13.667x + 2x^2$$

For V_M to be minimum, its differential coefficient w.r.t. x must be zero.

$$\frac{d}{dx}(2x^2 - 13.667\,x + 600) = 0$$

$$4x - 13.667 = 0$$

$$x = \frac{13.667}{4} = 3.417 \text{ km}$$

i.e., minimum potential occurs at a distance 3.417 km from substation A.

21. (a)

System capacitance upto circuit breaker,

$$C = \frac{B}{2\pi f} = \frac{9 \times 10^{-5}}{2\pi \times 50}$$

$$= 2.8647 \times 10^{-7} \text{ F}$$

System inductance upto circuit breaker,

$$L = \frac{X_L}{2\pi f} = \frac{18}{2\pi \times 50} = 0.05729 \text{ H}$$

Natural frequency of oscillation,

$$f_n = \frac{1}{2\pi\sqrt{LC}}$$

$$f_n = \frac{1}{2\pi\sqrt{(2.8647 \times 10^{-7}) \times (0.05729)}}$$

$$f_n = 1.242 \text{ kHz}$$

22. (d)

Inductance per loop meter is

$$L = 4 \times 10^{-7} \ln\left(\frac{d}{r'}\right) \text{H/m}$$

$$= 4 \times 10^{-4} \ln\left(\frac{d}{r'}\right) \text{ H/km}$$

When distance between the wires is increased as square of original distance, then new inductance per loop km is

$$L' = 4 \times 10^{-4} \ln\left(\frac{d^2}{r'}\right) \text{ H/km}$$

When distance between the wire is doubled new inductance per loop km is

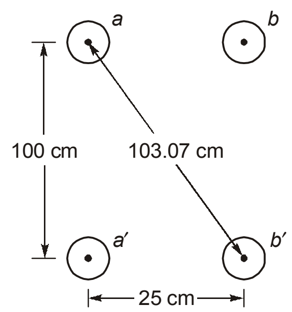
$$L' = 4 \times 10^{-4} \ln\left(\frac{2d}{r'}\right) \text{ H/km}$$

When, distance between the wire is increased four fold, new inductance per loop km is

$$= 4 \times 10^{-4} \ln\left(\frac{4d}{r'}\right) \text{ H/km}$$

So, none of these is correct.

23. (b)



GMR of conductor $= 0.7788 \times r$

$= 0.7788 \times 0.5 = 0.3894$ cm

Self GMD of aa' combination is,

$$D_s = \sqrt[4]{D_{aa} \cdot D_{aa'} \cdot D_{a'a'} \cdot D_{a'a}}$$

$$= \sqrt[4]{(0.3894)^2 \cdot (100)^2} = 6.2402 \text{ cm}$$

Mutual GMD between a and b,

$$= D_m = \sqrt[4]{D_{ab} \cdot D_{ab'} \cdot D_{a'b} \cdot D_{a'b'}}$$

$$= \sqrt[4]{(25)^2 \times (103.07)^2} = 50.76 \text{ cm}$$

Inductance per conductor per meter,

$$= 2 \times 10^{-7} \log_e \left(\frac{D_m}{D_s}\right)$$

$$= 2 \times 10^{-7} \log_e \left(\frac{50.76}{6.2402}\right) = 0.42 \times 10^{-6} \text{ H}$$

∴ loop inductance per km of the line

$$= 2 \times 0.42 \times 10^{-6} \times 1000 = 0.84 \text{ mH}$$

24. **(c)**

Transmission line parameters,

$$V_s = AV_r + BI_r \qquad \text{...(i)}$$

There is no load current but current flowing through the shunt inductor is I_L.

Now equation (i) becomes,

$$V_s = AV_r + BI_L$$

Dividing the above equation with I_L on both sides.

$$\frac{V_s}{I_L} = A\frac{V_r}{I_L} + B\frac{I_L}{I_L}$$

Since, $V_S = V_R$

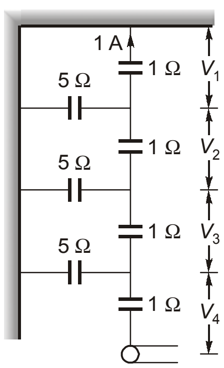
$$X_L = AX_L + B$$

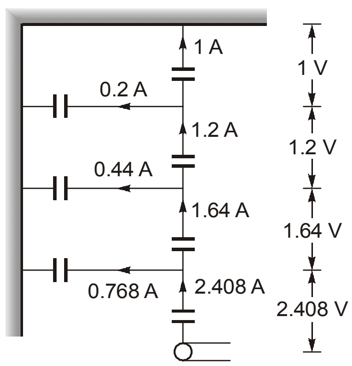
$$X_L(1 - A) = B$$

$$X_L = \frac{B}{1-A} = \frac{160}{1-0.95} = 3200\ \Omega$$

25. **(b)**

The ratio of self capacitance (c) to pin-earth capacitance (c_1) is $\frac{c}{c_1} = 5$. Suppose X_c = 1 Ω, then X_{c1} = 5 Ω. Suppose the voltage V across the string is such that current in the top insulator is 1 A as shown below then the potential across various insulators will be as shown below,





The voltage obtained across the string is

$$V = 1 + 1.2 + 1.64 + 2.408$$

$$V = 6.248 \text{ V}$$

$\therefore$ String efficiency $= \dfrac{6.248}{4 \times 2.408} \times 100$

$$\eta = 64.86\%$$

26. (b)

Reactive power injected into transmission line by generator = Q_t

$$Q_t = \frac{V_1^2}{X} - \frac{V_1 V_2}{X}\cos\delta$$

$$P_t = \frac{V_1 V_2}{X}\sin\delta$$

$$2 = \frac{1}{0.1}\sin\delta$$

$\Rightarrow$ $\sin\delta = 0.2$

$\Rightarrow$ $\cos\delta = \sqrt{0.96} \approx 0.98$

$$Q_t = 10 - 10 \times 0.98 = 0.20 \text{ p.u.}$$

Active power delivered by generator is

$$P_s = P_{D1} + P_{D2} = 3 \text{ p.u.}$$

Reactive power delivered by generator is

$$Q_S = Q_{D1} + Q_t = 1.2020 \text{ p.u.}$$

So, pf of generator $= \dfrac{P}{\sqrt{P^2 + Q^2}} = \dfrac{3}{\sqrt{3^2 + 1.20^2}} = 0.9284$ lag

27. (b)

At no-load, $I_R = 0$

$$A = \left|\frac{V_S}{V_R}\right| = \left|\frac{220}{242}\right| = \frac{10}{11}$$

and $A \approx 1 + \dfrac{YZ}{2}$

$$\frac{10}{11} = 1 + \frac{l^2(yz)}{2} = 1 + \frac{l^2(j0.4 \times j2.8 \times 10^{-6})}{2}$$

$$\frac{10}{11} = 1 - 0.56 \times 10^{-6}\, l^2$$

$$l \approx \sqrt{\frac{1}{11 \times 0.56 \times 10^{-6}}} = 402.91 \text{ km}$$

28. (b)

Mutual inductance, $L_m = 0.2\ln\frac{1}{D}$ mH/km

$D \rightarrow$ Distance between the conductors

$$L_m = 0.2\ \ln\frac{1}{4} = -0.4\ \ln 2$$

$$= -0.4 \times 0.69 = -0.276 \text{ mH/km}$$

29. (c)

$$\frac{\Delta P_D}{\Delta f} = -\left(B + \frac{1}{R}\right)$$

$$= -\left(2 + \frac{1}{0.025}\right) \qquad \begin{cases} R = \text{speed regulation paramters} \\ B = \text{load frequency constant} \end{cases}$$

$$\text{Slope} = \frac{\Delta P_D}{\Delta f} = -\left(2 + \frac{1000}{25}\right) = -42 \text{ MW/Hz}$$

30. (a)

For short term planning problem, losses can be found out by using approximate loss formula given by (for a two bus system)

$$P_{\text{loss}} = B_{11}P_1^2 + 2B_{12}P_1P_2 + B_{22}P_2^2$$

■■■■