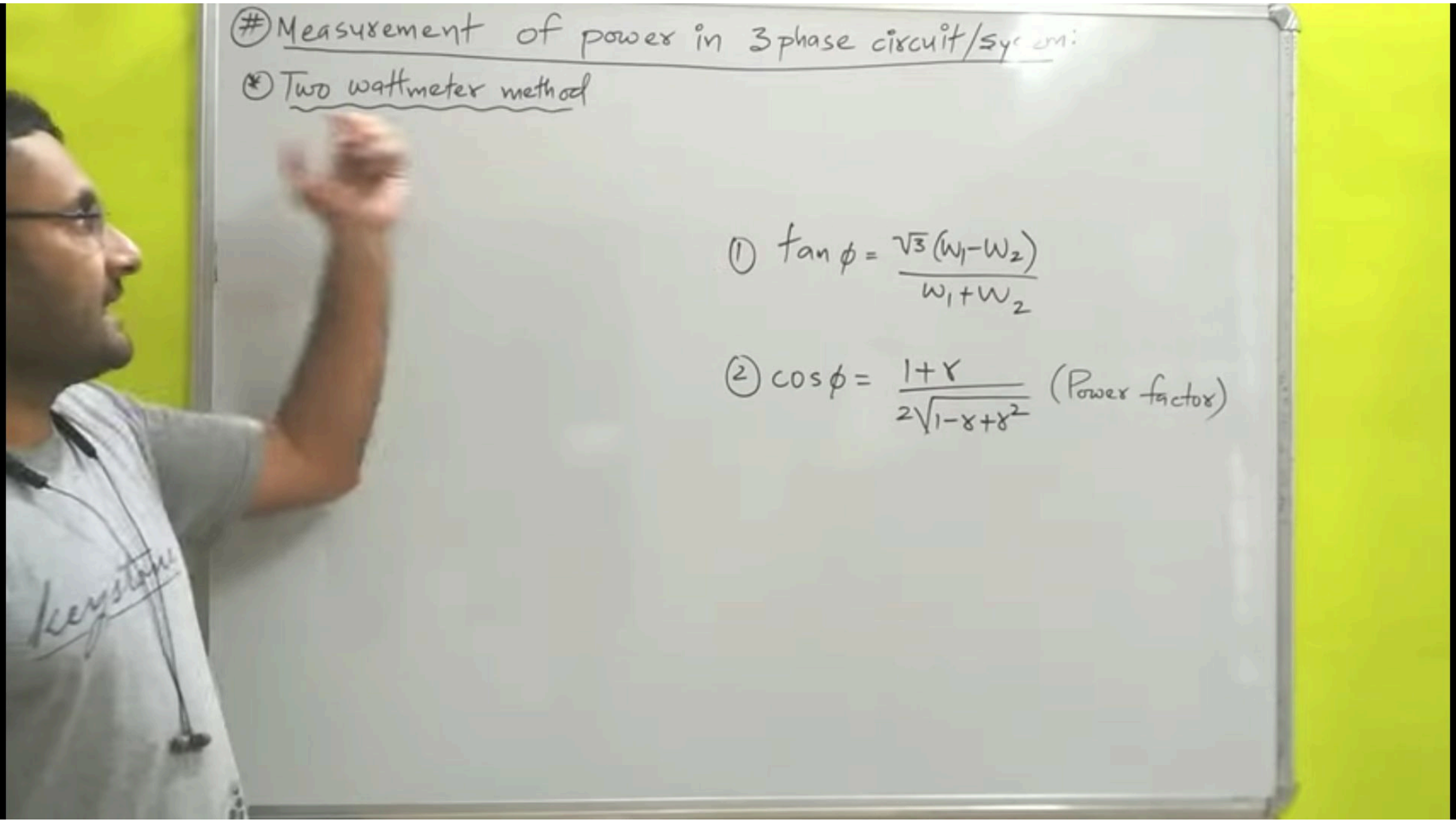
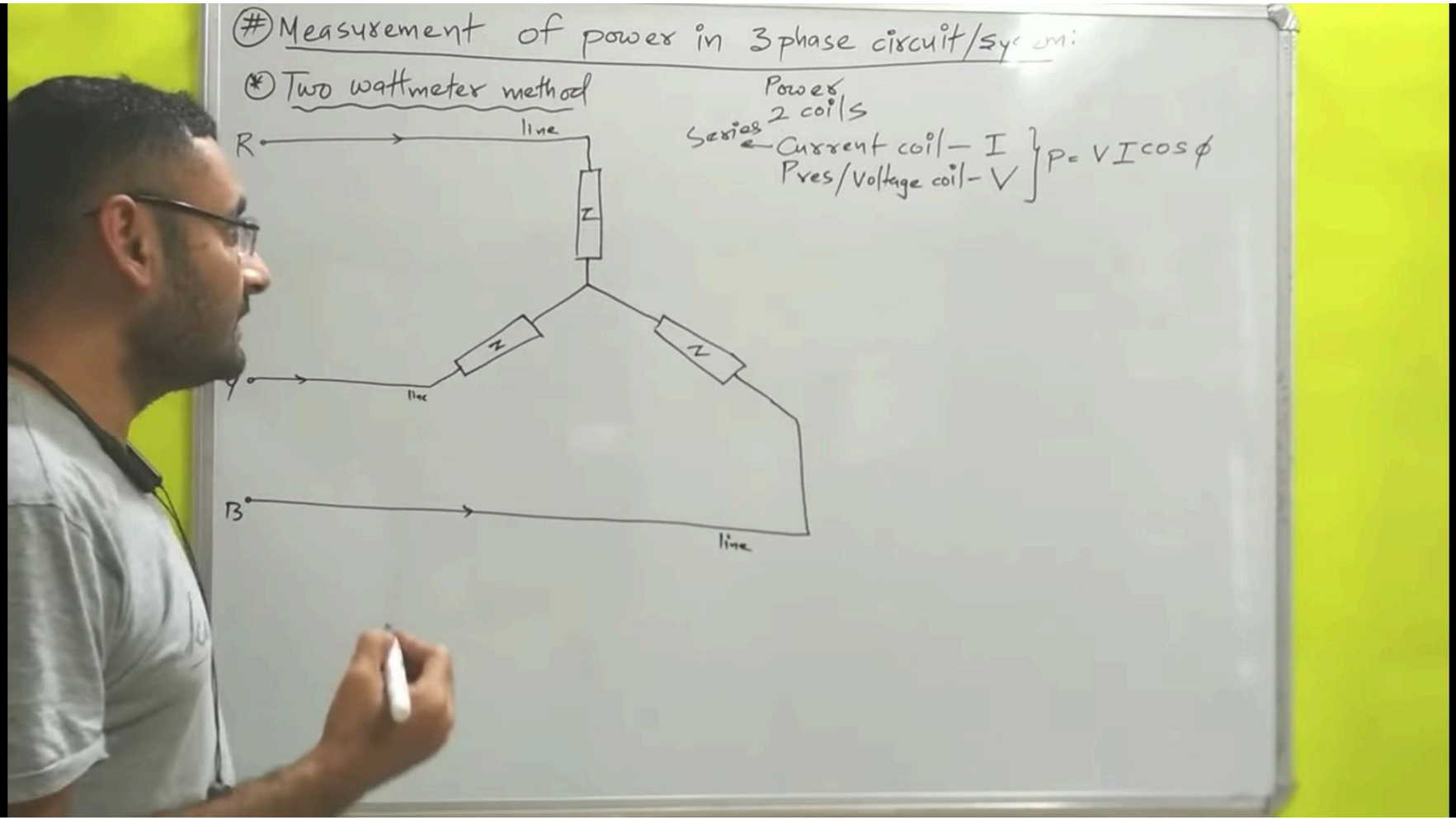
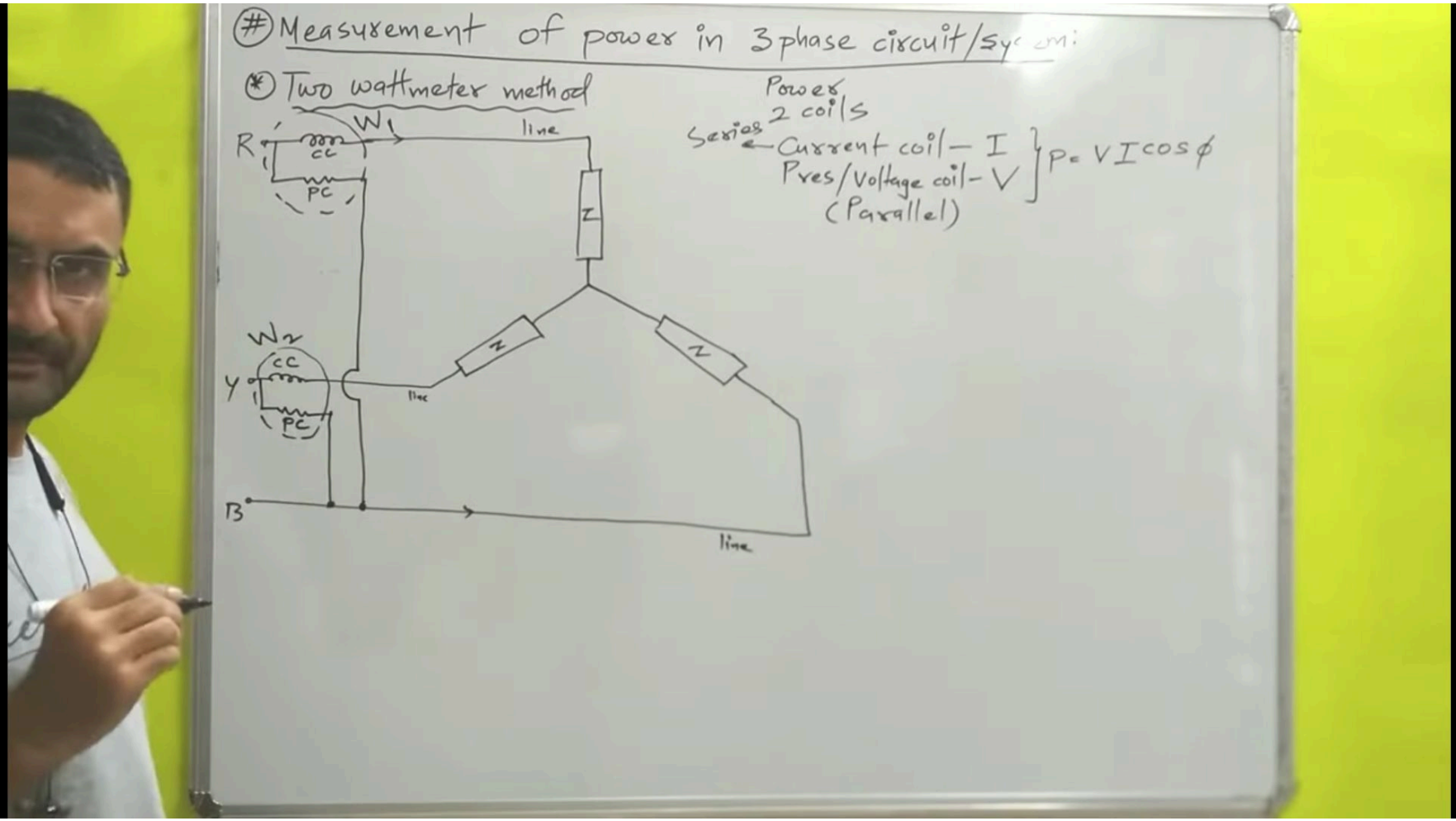
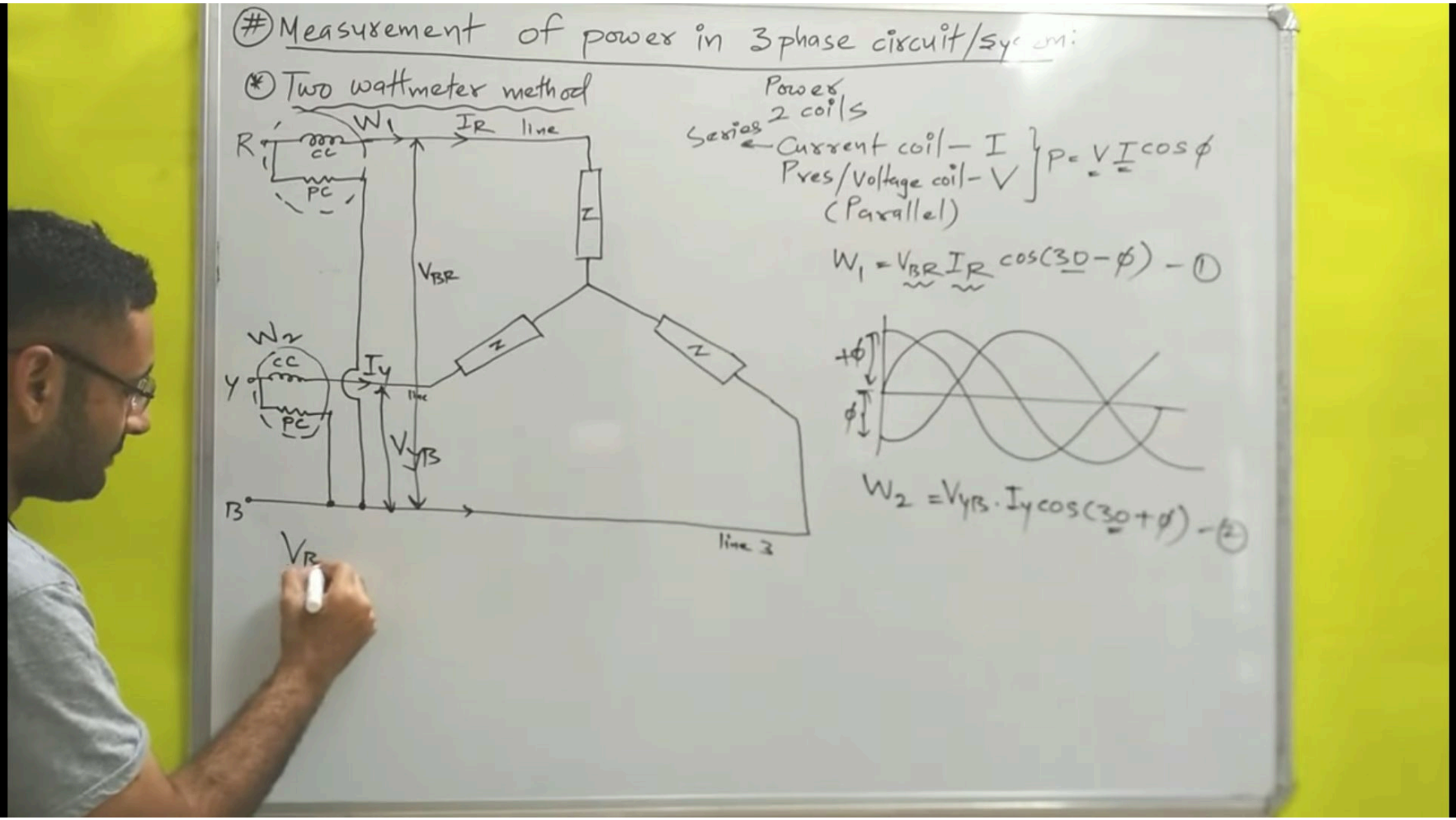

#Measurement of power in 3phase circuit/system:
*Two wattmeter method
① $\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}$
② $\cos\phi = \frac{1+x}{2\sqrt{1-x+x^2}}$ (Power factor)

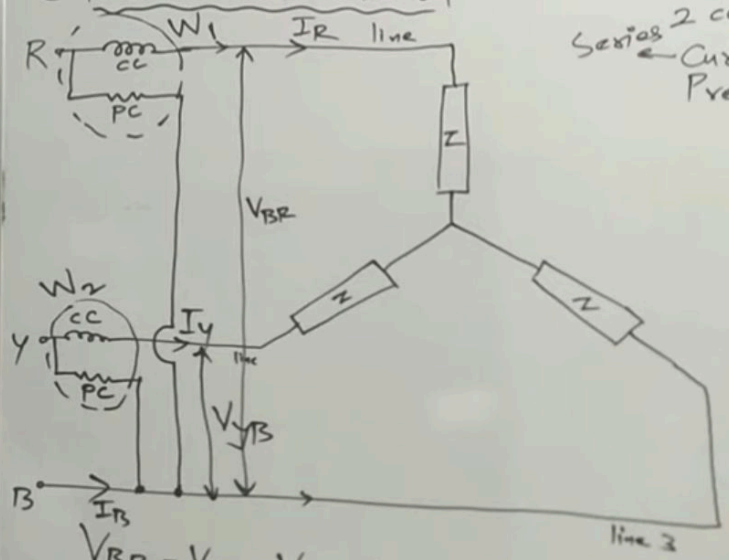

#Measurement of power in 3phase circuit/system:
*Two wattmeter method
Power
2 coils
Series ← Current coil – I
Pres/Voltage coil – V
P = VI cos ϕ
R
line
Z
Z
Z
Y
line
B
line


#Measurement of power in 3phase circuit/sy
*Two wattmeter method
Power
2 coils
Series ← Current coil – I
Pres/Voltage coil – V
(Parallel)
P = VI cos ϕ
R
W1
CC
PC
line
Z
Z
Z
W2
CC
PC
Y
line
B
line


#Measurement of power in 3phase circuit/system:
*Two wattmeter method
W1
IR line
R
CC
PC
Z
VBR
W2
CC
Y
PC
Iy
line
Z
Z
VyB
B
line 3
VR
Power
2 coils
Series ← Current coil – I
Pres/Voltage coil – V
(Parallel)
P = V I cos φ
W1 = VBR IR cos(30 – φ) – (1)
+φ
φ
W2 = VyB · Iy cos(30 + φ) – (2)

Measurement of power in 3phase circuit/system:

Two wattmeter method



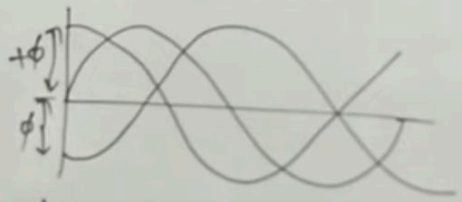
$W_1 = V_L I_L \cos(30-\phi)$

$W_2 = V_L I_L \cos(30+\phi)$

Power
2 coils
Series ← Current coil – I
Pres/Voltage coil – V
(Parallel)

$P = VI\cos\phi$

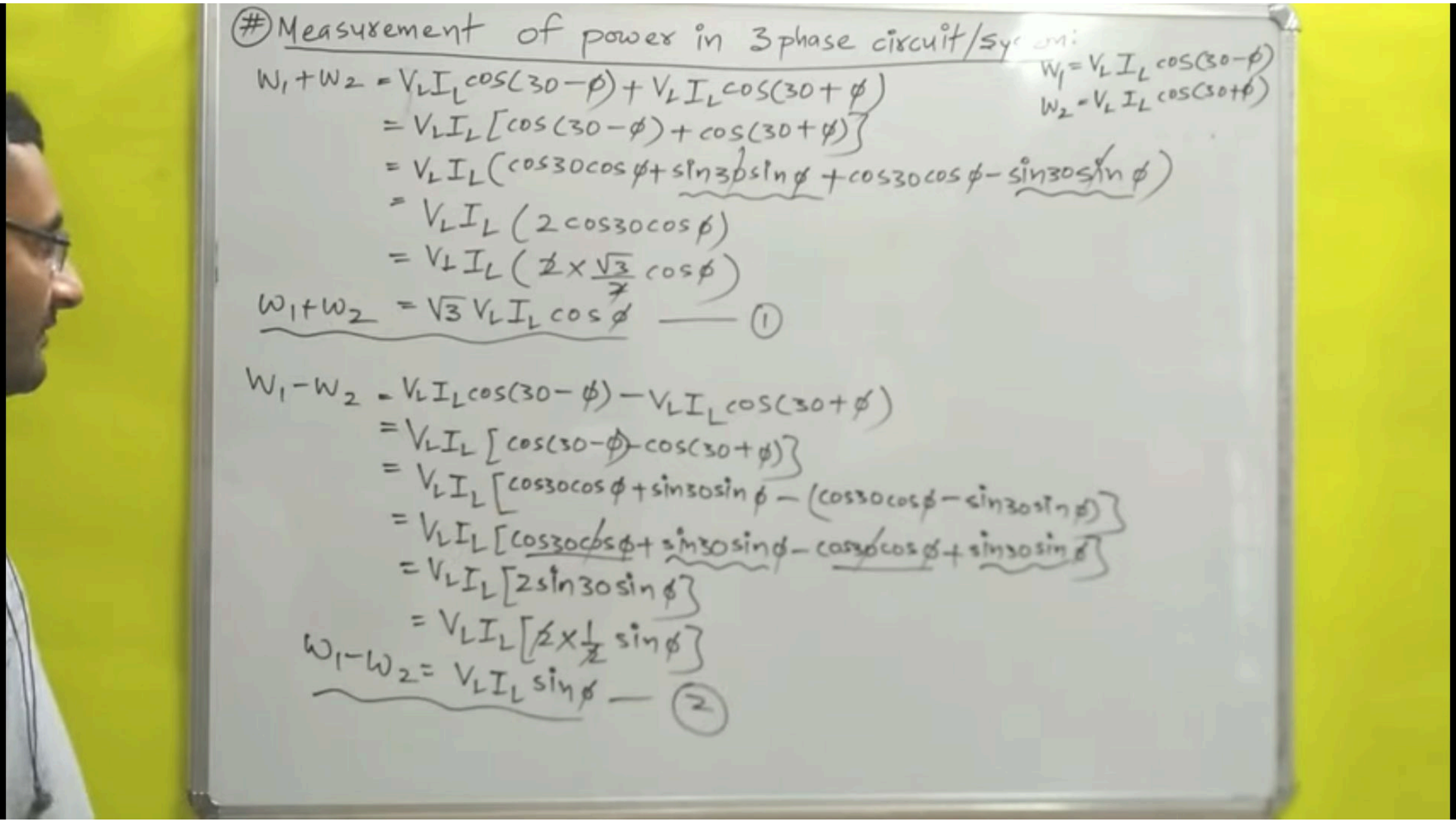
$W_1 = V_{BR} I_R \cos(30-\phi)$ – (1)



$W_2 = V_{yB} \cdot I_y \cos(30+\phi)$ – (2)

$V_{BR} = V_{RY} = V_{yB} = V_L$

$I_R = I_y = I_B = I_L$


#Measurement of power in 3phase circuit/system:
$W_1 = V_L I_L \cos(30-\phi)$
$W_2 = V_L I_L \cos(30+\phi)$
$W_1 + W_2 = V_L I_L \cos(30-\phi) + V_L I_L \cos(30+\phi)$
$= V_L I_L [\cos(30-\phi) + \cos(30+\phi)]$
$= V_L I_L (\cos30\cos\phi + \sin30\sin\phi + \cos30\cos\phi - \sin30\sin\phi)$
$= V_L I_L (2\cos30\cos\phi)$
$= V_L I_L (2 \times \frac{\sqrt{3}}{2} \cos\phi)$
$W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi$ ——— (1)
$W_1 - W_2 = V_L I_L \cos(30-\phi) - V_L I_L \cos(30+\phi)$
$= V_L I_L [\cos(30-\phi) - \cos(30+\phi)]$
$= V_L I_L [\cos30\cos\phi + \sin30\sin\phi - (\cos30\cos\phi - \sin30\sin\phi)]$
$= V_L I_L [\cos30\cos\phi + \sin30\sin\phi - \cos30\cos\phi + \sin30\sin\phi]$
$= V_L I_L [2\sin30\sin\phi]$
$= V_L I_L [2 \times \frac{1}{2} \sin\phi]$
$W_1 - W_2 = V_L I_L \sin\phi$ ——— (2)

(#) Measurement of power in 3phase circuit/system:

$W_1 = V_L I_L \cos(30-\phi)$

$W_2 = V_L I_L \cos(30+\phi)$

$W_1 + W_2 = V_L I_L \cos(30-\phi) + V_L I_L \cos(30+\phi)$

$= V_L I_L [\cos(30-\phi) + \cos(30+\phi)]$

$= V_L I_L (\cos 30\cos\phi + \sin 30\sin\phi + \cos 30\cos\phi - \sin 30\sin\phi)$

$= V_L I_L (2\cos 30\cos\phi)$

$= V_L I_L \left(2 \times \frac{\sqrt{3}}{2} \cos\phi\right)$

$W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi$ — (1)

$W_1 - W_2 = V_L I_L \cos(30-\phi) - V_L I_L \cos(30+\phi)$

$= V_L I_L [\cos(30-\phi) - \cos(30+\phi)]$

$= V_L I_L [\cos 30\cos\phi + \sin 30\sin\phi - (\cos 30\cos\phi - \sin 30\sin\phi)]$

$= V_L I_L [\cos 30\cos\phi + \sin 30\sin\phi - \cos 30\cos\phi + \sin 30\sin\phi]$

$= V_L I_L [2\sin 30\sin\phi]$

$= V_L I_L \left[2 \times \frac{1}{2} \sin\phi\right]$

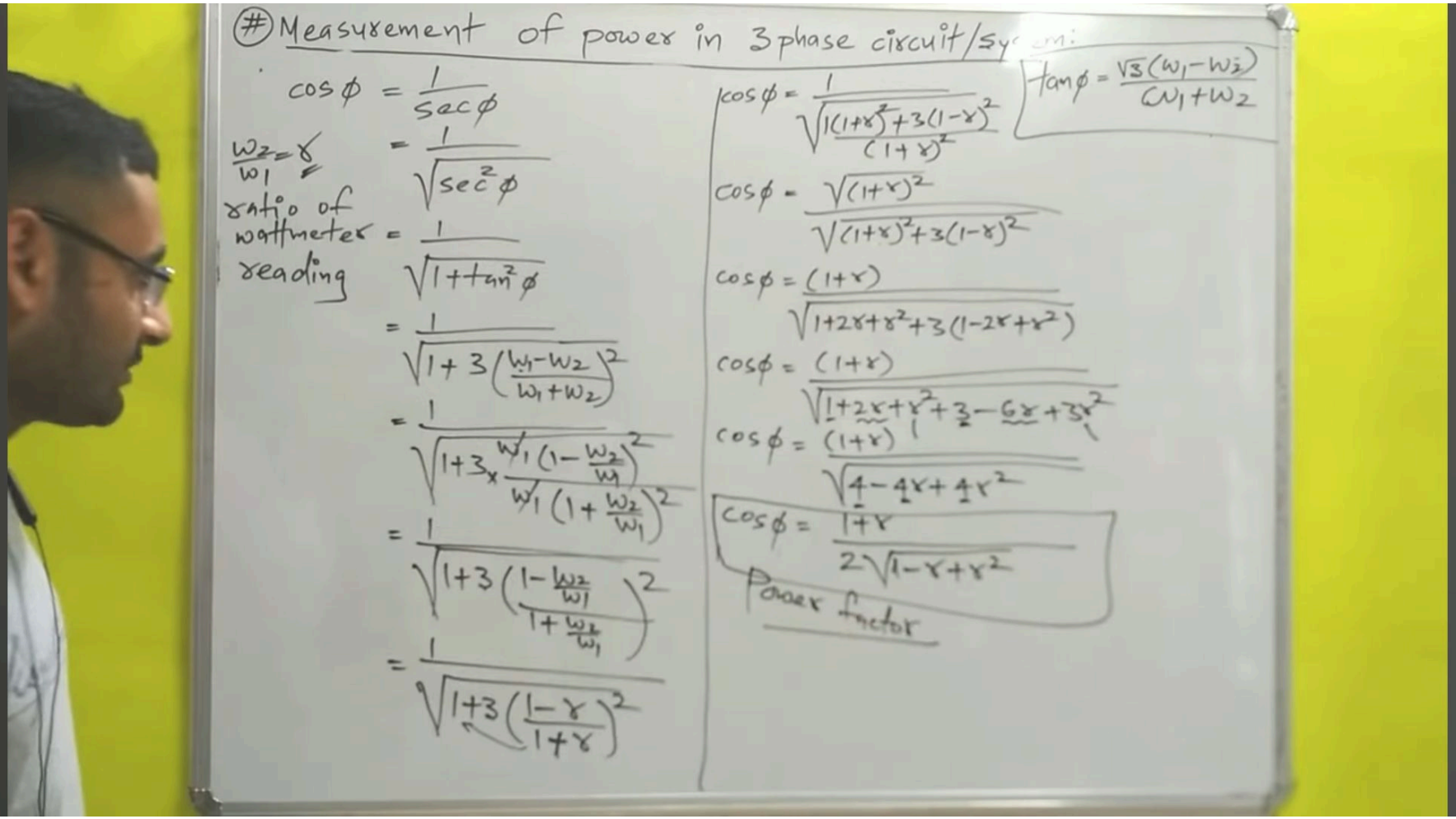
$W_1 - W_2 = V_L I_L \sin\phi$ — (2)

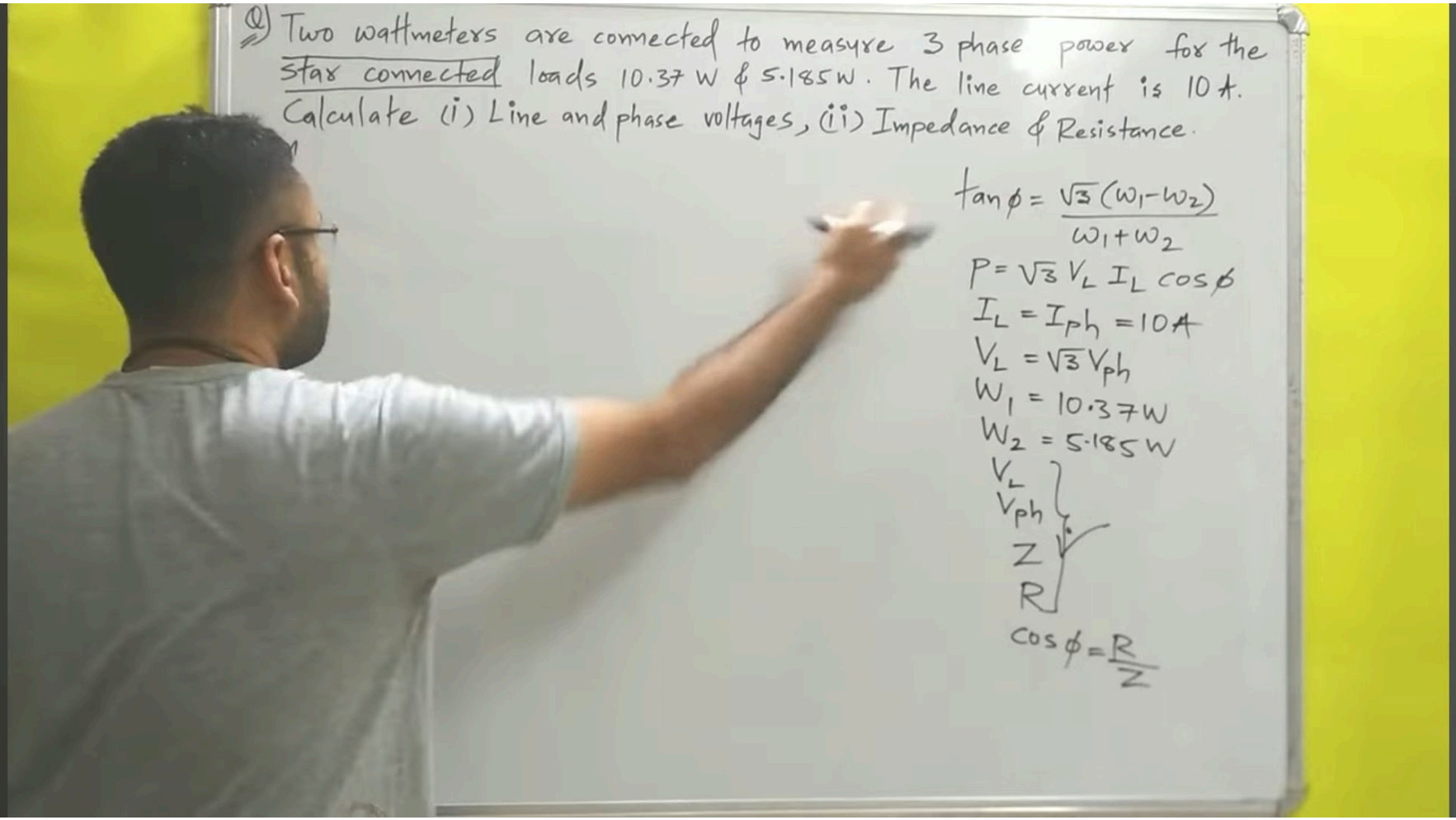
(2) ÷ (1)

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I_L \sin\phi}{\sqrt{3} V_L I_L \cos\phi}$$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{\tan\phi}{\sqrt{3}}$$

$$\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}$$


#Measurement of power in 3phase circuit/system:
cosφ = 1/secφ
= 1/√sec²φ
ratio of wattmeter reading = 1/√1+tan²φ
= 1/√1+3((W1-W2)/(W1+W2))²
= 1/√1+3 W1(1-W2/W1)² / W1(1+W2/W1)²
= 1/√1+3((1-W2/W1)/(1+W2/W1))²
= 1/√1+3((1-γ)/(1+γ))²
W2/W1 = γ
cosφ = 1/√1(1+γ)²+3(1-γ)² / (1+γ)²
cosφ = √(1+γ)² / √(1+γ)²+3(1-γ)²
cosφ = (1+γ) / √1+2γ+γ²+3(1-2γ+γ²)
cosφ = (1+γ) / √1+2γ+γ²+3-6γ+3γ²
cosφ = (1+γ) / √4-4γ+4γ²
cosφ = 1+γ / 2√1-γ+γ²
Power factor
tanφ = √3(W1-W2)/(W1+W2)


Q) Two wattmeters are connected to measure 3 phase power for the star connected loads 10.37 W & 5.185 W. The line current is 10 A. Calculate (i) Line and phase voltages, (ii) Impedance & Resistance.
$\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}$
$P = \sqrt{3} V_L I_L \cos\phi$
$I_L = I_{ph} = 10A$
$V_L = \sqrt{3} V_{ph}$
$W_1 = 10.37W$
$W_2 = 5.185W$
V_L
V_{ph}
Z
R
$\cos\phi = \frac{R}{Z}$

Q) Two wattmeters are connected to measure 3 phase power for the star connected loads 10.37 W & 5.185 W. The line current is 10 A. Calculate (i) Line and phase voltages, (ii) Impedance & Resistance.

Sol^n ⟹ $\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \frac{\sqrt{3}(10.37 - 5.185)}{(10.37 + 5.185)}$

$\tan\phi = 0.57735$

$\phi = \tan^{-1}(0.57735)$

$\phi = 30$

Power factor $\cos\phi \rightarrow \cos(30)$

$\cos\phi = 0.8660$

$P = \sqrt{3} V_L I_L \cos\phi$

$15.555 = \sqrt{3} \times V_L \times 10 \times 0.8660$

$V_L = \frac{15.555}{\sqrt{3} \times 10 \times 0.8660}$

$V_L = 1.03$ Volt Ans

$V_L = \sqrt{3} V_{ph}$

$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{1.03}{\sqrt{3}}$

$V_{ph} = 0.59$ Volts Ans

$P = W_1 + W_2$

$= 10.37 + 5.185$

$P = 15.555$ W

$V_{ph} = I_{ph} Z$

$Z = \frac{V_{ph}}{I_{ph}}$

$= \frac{0.59}{10}$

$Z = 0.059\ \Omega$ Ans

$\cos\phi = \frac{R}{Z}$

$R = \cos\phi \, Z$

$= 0.8660 \times 0.059$

$R = 0.051\ \Omega$ Ans

$\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}$

$P = \sqrt{3} V_L I_L \cos\phi$

$I_L = I_{ph} = 10$ A

$V_L = \sqrt{3} V_{ph}$

$W_1 = 10.37$ W

$W_2 = 5.185$ W

$\cos\phi = \frac{R}{Z}$