

ECE 260 course overview

Key points for <https://lessons.ihsan.cc/ece260/ece260-course-overview/>: the schedule and marks, one formula block per module, and the highest-value worked examples and practice problems.

ECE 260 at a glance

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Lectures Mon + Fri 11:30–12:50, Sep 9 – Dec 8, PSE 4043, plus six Thursday lectures (12:30–13:20). Labs run 08:30–11:20 in CPH 1333 on a per-section day.

LABS: DATES AND THE MARKS THEY CARRY

LAB	TOPIC	IN THE LAB	REPORT DUE
L1	1-ph circuits	Sep 21–24	Mon Oct 19
L2	3-ph circuits & PF	Oct 5–8	Fri Oct 23
L3	1-ph transformer	Nov 2–5	Fri Nov 13
L4	DC motor	Nov 16–19	Fri Nov 27
L5	AC machines	Nov 30 – Dec 3	Tue Dec 8

COMPONENT	WEIGHT	DATE
Labs	20%	five dated windows, above
Quizzes	5%	not in the outline yet
Midterm Exam	25%	during the exam schedule; not scheduled yet
Final Exam	50%	during the exam schedule; not scheduled yet

All five labs are mandatory, in groups of two, and **failing to complete one is an NCR** – no credit for the course, whatever else you earned. A missed assessment without documentation scores zero; a documented missed midterm moves the final to 75%. Generative AI is not permitted on any assessment.

Six quizzes run in the tutorials (lowest dropped), based on the Friday problem sets. Exams allow one single-sided formula sheet and a complex-arithmetic calculator only.

Power systems and AC circuit concepts

Modules 1–2: generation at 13.8–24 kV, meshed transmission at 230–765 kV, radial distribution down to 120–480 V; then the circuit language every later module is written in.

A lowercase symbol is instantaneous, a capital is RMS.

$$v(t) = \sqrt{2} V \cos(\omega t), \quad i(t) = \sqrt{2} I \cos(\omega t - \varphi), \quad Z = \frac{\bar{V}}{\bar{I}} = |Z| \angle \theta$$

Real power P is the non-zero average of $p(t)$; reactive power Q is borrowed and returned each cycle. The conjugate goes on the current, which is the sign convention the rest of the module reads off:

KEY RELATION

$$S = \bar{V} \bar{I}^* = P + jQ, \quad P = VI \cos \varphi \text{ [W]}, \quad Q = VI \sin \varphi \text{ [VAR]}$$

$Q > 0$ (current lags) means the circuit absorbs reactive power, inductive; $Q < 0$ (current leads) means it supplies reactive power, capacitive. For a series branch $Z = R + jX$: $P = I^2 R$, $Q = I^2 X$, $\tan \varphi = X/R$.

A balanced three-phase source is three sinusoids 120 degrees apart. A star (Y) connection separates voltages, $V_L = \sqrt{3} V_{ph}$ leading by 30° , with $I_L = I_{ph}$; a delta separates currents, $V_L = V_{ph}$ with $I_L = \sqrt{3} I_{ph}$ lagging by 30° . A per-phase circuit needs a wye load; convert a delta first with $Z_\Delta = 3Z_Y$ (balanced only).

$$P_{total} = \sqrt{3} V_L I_L \cos \theta = 3 V_{ph} I_{ph} \cos \theta, \quad Q_{total} = \sqrt{3} V_L I_L \sin \theta$$

The line form does *not* extend to complex power: $S_{total} = 3 \bar{V}_{ph} \bar{I}_{ph}^* \neq \sqrt{3} \bar{V}_L \bar{I}_L^*$ (same magnitude, wrong angle).

MODULE 2, EXAMPLE 4 (FILED SLIDES, P. 60)

In a balanced three-phase circuit, $\bar{V}_{ab} = 173.2 \angle 0^\circ$ V. Determine all the phase and line voltages and currents in a Y-connected load having $Z_L = 10 \angle 20^\circ \Omega$.

Since $\bar{V}_{ab} = \sqrt{3} \bar{V}_{an} \angle 30^\circ$:

$$\bar{V}_{an} = \frac{173.2}{\sqrt{3}} \angle (0^\circ - 30^\circ) = 100 \angle -30^\circ \text{ V}, \quad \bar{V}_{bn} = 100 \angle -150^\circ, \quad \bar{V}_{cn} = 100 \angle -270^\circ \text{ V}$$

$$\bar{V}_{ab} = 173.2 \angle 0^\circ, \quad \bar{V}_{bc} = 173.2 \angle -120^\circ, \quad \bar{V}_{ca} = 173.2 \angle -240^\circ \text{ V}$$

In a wye load the line current is the phase current:

$$\bar{I}_a = \frac{100 \angle -30^\circ}{10 \angle 20^\circ} = 10 \angle -50^\circ \text{ A}, \quad \bar{I}_b = 10 \angle -170^\circ, \quad \bar{I}_c = 10 \angle -290^\circ \text{ A}$$

The load is balanced, so $\bar{I}_n = 0$.

Magnetic circuits

Module 3.

A coil of N turns carrying I drives flux around a core exactly as an EMF drives current through a resistive network:

KEY RELATION

$$\mathcal{F} = NI, \quad \mathcal{R} = \frac{l}{\mu A}, \quad \Phi = \frac{\mathcal{F}}{\mathcal{R}}$$

Air's permeability is about a thousand times smaller than iron's, so a millimetre of air gap out-reluctances the iron path around it – almost all the mmf is spent crossing the gap. The analogy breaks under saturation, fringing and leakage. Faraday's law with Lenz's sign:

$$e = -\frac{d\lambda}{dt} = -N \frac{d\Phi}{dt}, \quad \lambda = N\Phi$$

Transformers

Module 4.

An ideal transformer's turns ratio scales voltage directly and current inversely; an impedance seen through it scales by the square:

KEY RELATION

$$a = \frac{N_1}{N_2}, \quad \frac{V_1}{V_2} = a, \quad \frac{I_1}{I_2} = \frac{1}{a}, \quad Z_1 = a^2 Z_2$$

A real one adds series winding R and leakage X , and a shunt $R_c \parallel jX_m$. Open-circuit test gives core loss and the shunt branch; short-circuit gives series R and X .

DC machines

Module 5.

Two equations, sharing one constant K , carry the module:

KEY RELATION

$$E_a = K\phi\omega, \quad T = K\phi I_a, \quad E_a I_a = T\omega$$

$$\text{motor: } V_t = E_a + I_a R_a \quad \text{generator: } V_t = E_a - I_a R_a$$

At standstill $E_a = 0$, so $I_a = V_t/R_a$ is many times rated – hence starting resistance. Since $\omega = (V_t - I_a R_a)/(K\phi)$, weakening the field *raises* speed (ϕ in the denominator); an unloaded series motor can run away.

Synchronous machines

Module 6.

The rotating stator field turns only at synchronous speed; the rotor must match it exactly or average torque is zero:

KEY RELATION

$$n_s = \frac{120f}{p} [\text{rpm}], \quad \bar{E}_f = \bar{V}_t + jX_s \bar{I}_a \text{ (generator)}, \quad P = \frac{3E_f V_t}{X_s} \sin \delta$$

Power peaks at $\delta = 90^\circ$; past it the machine loses synchronism (the steady-state stability limit). On a stiff grid the prime mover fixes real power and hence δ ; the field current instead controls reactive power – over-excite and the machine supplies Q with a lagging armature current, under-excite and it absorbs Q with a leading current.

Induction motors

Module 7.

If the rotor turned at synchronous speed it would see no changing flux, so no induced current and no torque – it must run slower, by the slip:

KEY RELATION

$$s = \frac{n_s - n}{n_s}, \quad \frac{R_2}{s} = R_2 + R_2 \frac{1-s}{s}$$

The first piece is rotor copper loss; the second is where mechanical power leaves the circuit. Torque as a function of slip:

$$T = \frac{3}{\omega_s} \cdot \frac{V_1^2(R_2/s)}{(R_1 + R_2/s)^2 + (X_1 + X_2)^2}, \quad s_{max} = \frac{R_2}{\sqrt{R_1^2 + (X_1 + X_2)^2}}$$

R_2 cancels when s_{max} is substituted back: rotor resistance moves *where* breakdown torque sits, not *how high* – wound-rotor starting. Torque goes as V_1^2 .

Practice problems

From the lesson's check-yourself questions, same numbers.

1. A load draws a current that leads its terminal voltage. State the sign of Q and whether the load absorbs or supplies reactive power.

Answer: Leading current means $\varphi < 0$, so $Q = VI \sin \varphi < 0$: the load supplies reactive power (capacitive).

2. A balanced delta load of $30\angle 40^\circ \Omega$ per phase sits on a 208 V line. What impedance goes into the per-phase equivalent circuit, and what voltage does that circuit see?

Answer: $Z_Y = Z_\Delta/3 = 10\angle 40^\circ \Omega$ (angle unchanged); the circuit is drawn line-to-neutral, so it sees $208/\sqrt{3} = 120.1$ V.

3. A transformer has $a = 10$. A 5Ω load sits on the secondary. Predict the impedance the primary source sees.

Answer: $Z_1 = a^2 Z_2 = 100 \times 5 = 500 \Omega$, not 50Ω .

4. A shunt DC motor runs at steady speed on a fixed terminal voltage. You reduce the field current. Predict what happens to the speed, and name the term that drives it.

Answer: The speed rises: with V_t fixed, $\omega = (V_t - I_a R_a)/(K\phi)$, and ϕ is in the denominator.

5. A 4-pole 60 Hz induction motor runs at 1728 rpm. Compute the slip and the fraction of air-gap power lost as rotor copper loss.

Answer: $n_s = 120 \times 60/4 = 1800$ rpm, $s = (1800 - 1728)/1800 = 0.04$, so 4% of the air-gap power is rotor copper loss.