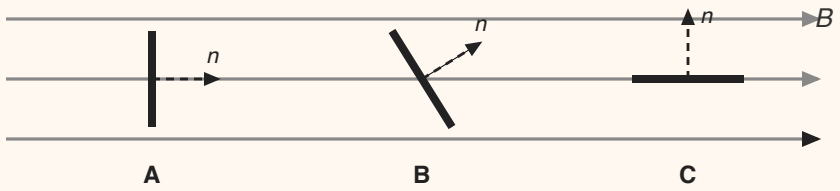
INDUCTION DAY 1: MAGNETIC FLUX

WARMUP Counting Through a Window

Electric flux counted E-lines through a surface (Gauss). Magnetic flux counts B-lines threading a LOOP — like light through a window. Rank the flux through loops A, B, and C below, and defend the zero: B is at full strength there, so what makes Φ vanish?



One loop, seen edge-on at three orientations in the same uniform field; each dashed arrow is the loop's normal n.

MAGNETIC FLUX

$\Phi = \int B \cdot dA = BA\cos\theta$ (uniform B) — θ between B and the loop's NORMAL. Unit: the weber, 1 Wb = 1 T·m².

Three ways to change Φ — and this unit is about CHANGING it: change B, change A, or change θ. Rotation makes Φ a cosine of time.

No magnetic monopoles: through any CLOSED surface, $\Phi_B = 0$ always — every line that enters exits.

WE DO Exercise 1: Flux Reps

A 1.0 m × 1.0 m loop in B = 0.5 T. Φ when the normal is **(a)** aligned with B: _____. **(b)** at 60°: _____. **(c)** at 90°: _____.

CHANGING THE COUNT

WE DO Exercise 2: Three Knobs

A 0.2 m² loop starts with its normal along B = 0.4 T (Φ = 0.08 Wb). Find $\Delta\Phi$ for each move: **(a)** B doubles. **(b)** the loop is folded to half area. **(c)** the loop rotates so $\theta = 60°$.

YOU DO Exercise 3: The Cosine Clock

A square loop (A = 1.0 m², B = 0.5 T) spins at ω = 2.0 rad/s, so $\Phi = 0.5\cos(2t)$ Wb. Find Φ at t = 0, at t = $\pi/4$ s, and at t = $\pi/2$ s — then sketch one full period.

CALC Exercise 4: Non-Uniform B

A square loop (side 0.2 m) lies in a field B(x) = 2.0x T (increasing across the loop's width, from x = 0 to x = 0.2 m). Compute $\Phi = \int B\,dA = \int_0^{0.2} (2.0x)(0.2)dx$ — the integral flux definition earning its keep.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Straight Count

A 0.3 m × 0.4 m loop, normal along B = 0.25 T: find Φ.

P2 With the Angle

The same loop tilted so its normal makes 37° with B (cos37° = 0.8): find Φ.

P3 Solve for B

A 0.5 m² loop (normal aligned) needs Φ = 0.2 Wb. What B?

P4 The Closed-Surface Zero

A cube sits in a strong uniform field: 0.8 T entering one face (area 0.04 m²) head-on. Find the flux IN through that face, the flux OUT through the opposite face, and the total through the whole closed cube — then state the monopole moral.