LESSON MAKER PRO

Fields Through Surfaces

Calculate magnetic flux as a surface turns.

HIGH SCHOOL · HS-PSII-7.1

HS-PSII-7.1 "Given the magnitude and direction of a uniform magnetic field, calculate the flux through a specified area in terms of the field magnitude and the size and orientation of the area with respect to the field."

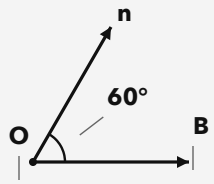
NAME _____ DATE _____

THE FLUX RULE

Magnetic flux is $\Phi = BA\cos\theta$, where B is the magnetic field strength, A is the surface area, and θ is the angle between the field and the surface normal, a line perpendicular to the surface. In a side view, a ray labeled surface lies along the surface; if α is the angle between that ray and B, use $\Phi = BA\sin\alpha$. Useful values are $\cos 0° = \sin 90° = 1$, $\cos 60° = \sin 30° = 1/2$, and $\cos 45° = \sqrt{2}/2$; 1 T·m^2 = 1 Wb.

WORKED EXAMPLE

A 3 T magnetic field crosses a surface with an area of 7 m^2. The figure shows the angle between the field and the surface normal. Find the magnetic flux.



1. Use $\Phi = BA\cos\theta$, with $\theta = 60°$.
2. Multiply B and A: (3 T)(7 m^2) = 21 T·m^2.
3. Multiply by $\cos 60°$: $\Phi = 21(1/2) = 10.5$ Wb.

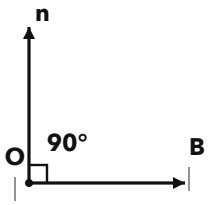
Answer: 10.5 Wb

PRACTICE 6 problems

1 A 2 T field points along the normal to a surface of area 4 m^2. Find the magnetic flux.

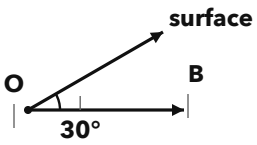
ANSWER _____

2 A 5 T field crosses a surface of area 6 m^2. The figure shows the angle between the field and the surface normal. Find the magnetic flux.



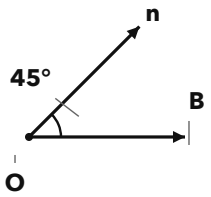
ANSWER _____

3 A 4 T field crosses a surface of area 10 m^2. The figure shows the angle between the field and a line along the surface. Find the magnetic flux.



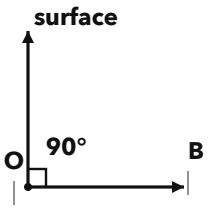
ANSWER _____

4 A 9 T field crosses a surface of area 2 m^2. The figure shows the angle between the field and the surface normal. Find the magnetic flux. Leave $\sqrt{2}$ in your answer.



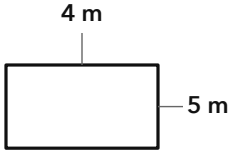
ANSWER _____

5 A 1 T field crosses a surface of area 12 m^2. The figure shows the angle between the field and a line along the surface. Find the magnetic flux.



ANSWER _____

6 A rectangular surface has the dimensions shown. A 6 T field points along its normal. Find the magnetic flux.



ANSWER _____

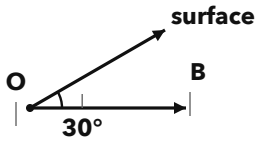
APPLY IT Show your work

1 At one instant, a wireless charging pad produces an approximately uniform 0.4 T magnetic field across a phone coil. The coil's area is 0.02 m^2, and the field points along its normal. What is the magnetic flux through the coil at that instant?

WORK SPACE

ANSWER _____

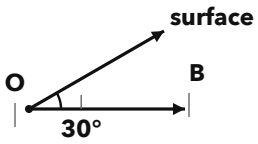
2 A student tests a magnetic sensor for an e-bike. At one instant, an approximately uniform 0.5 T field crosses the sensor's loop, which has an area of 0.04 m^2. The figure shows the angle between the field and a line along the loop's surface. What is the magnetic flux through the loop?



ANSWER _____

CHALLENGE One step up

A 4 T field crosses a rectangular loop that is 2 m long and 5 m wide. At first, the field makes the angle with the loop's surface shown in the figure. Then the loop turns until the field points along its normal. How much does the magnetic flux increase? Show the flux in each position.



WORK SPACE AND ANSWER

Fields Through Surfaces

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	A 2 T field points along the normal to a surface of area 4 m^2. Find the magnetic flux.	**8 Wb**
2	A 5 T field crosses a surface of area 6 m^2. The figure shows the angle between the field and the surface normal. Find the magnetic flux.	**0 Wb**
3	A 4 T field crosses a surface of area 10 m^2. The figure shows the angle between the field and a line along the surface. Find the magnetic flux.	**20 Wb**
4	A 9 T field crosses a surface of area 2 m^2. The figure shows the angle between the field and the surface normal. Find the magnetic flux. Leave $\sqrt{2}$ in your answer.	**$9\sqrt{2}$ Wb**
5	A 1 T field crosses a surface of area 12 m^2. The figure shows the angle between the field and a line along the surface. Find the magnetic flux.	**12 Wb**
6	A rectangular surface has the dimensions shown. A 6 T field points along its normal. Find the magnetic flux.	**120 Wb**

PART 2 · APPLY IT

1. **0.008 Wb** The field points along the normal, so $\cos\theta = 1$. $\Phi = (0.4)(0.02)(1) = 0.008$ Wb.
2. **0.01 Wb** Use the angle to the surface: $\Phi = BA \sin 30°$. Thus $\Phi = (0.5)(0.04)(1/2) = 0.01$ Wb.

CHALLENGE

The area is (2)(5) = 10 m^2. Initially, Φ = (4)(10) sin 30° = 20 Wb. With the field along the normal, Φ = (4)(10) = 40 Wb. The increase is 20 Wb.

Accept $T \cdot m^2$ in place of Wb. For the 45° problem, accept $18\sqrt{2}/2$ Wb as an equivalent exact answer.