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8. Equipotential Lines

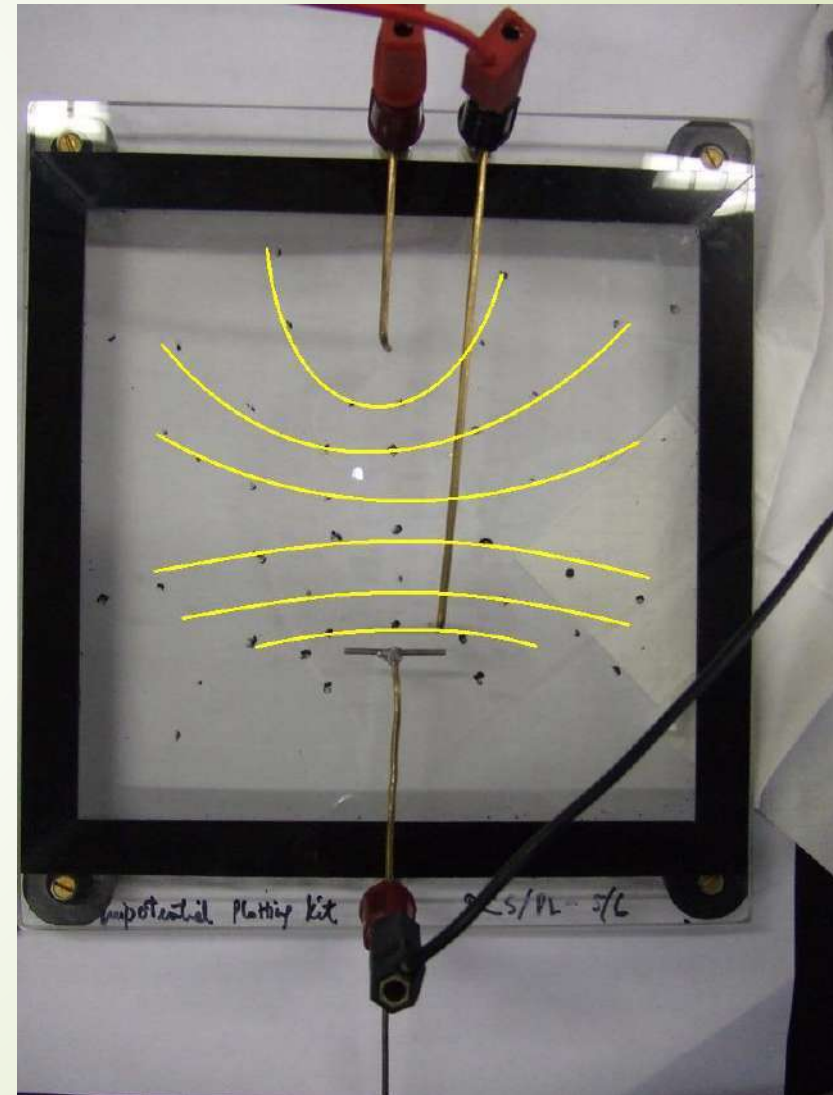
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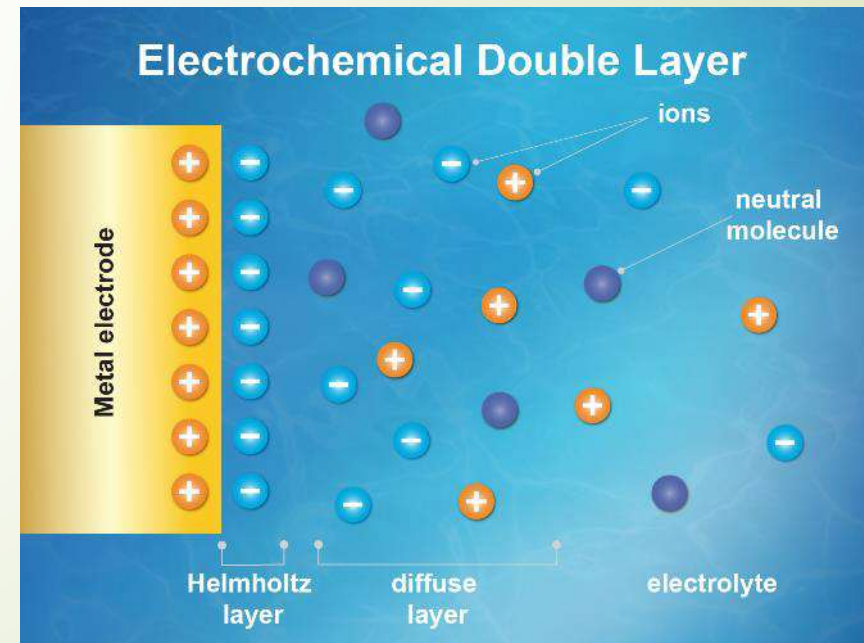
8. Equipotential Lines

Place **two electrodes into water**, supply a safe voltage and use a voltmeter to **determine electric potential** at various locations. Investigate how the measured equipotential lines **deviate from your expectations** for different conditions and **liquids**.



Equipotential Lines - experiment

- Metallic electrode in water – **polarisation** (electrochemical double layer)
- Some minimum voltage is needed to overcome the potential
- Only capacity at low voltages (<0.1V)
- DC current causes **electrolysis** at higher voltages
- **AC voltage** is the solution?





Equipotential Lines - experiment

- ▶ What to check:
 - ▶ Various electrodes, including inert (graphite?)
 - ▶ Various electrolytes (distilled water, salty water, ...)
 - ▶ Frequency of the AC voltage ($\sim 0.1 - 10$ kHz)
 - ▶ amplifier & PC sound card?)
 - ▶ Dedicated signal generator + voltmeter/oscilloscope



Equipotential Lines - theory

- How to calculate theoretical fields around electrodes with non-trivial geometry?
- Use suitable software – FEMM is free and good
- **FEMM (Finite Elements Magnetic Method)** was developed for calculations of magnetic fields, but can also calculate electrostatic fields and current fields
- If material follows Ohm's law: the potential field is the same as for **electrostatic field**
- If water depth is much smaller than the size of electrodes – **2D model** can be used



1 2 3 4 5 6 7 8

Equipotential Lines - FEMM

- 1. Start FEMM, File/New/Electrostatic problem
- 2. Menu Problem: set planar problem, units to cm or mm
- 3. Menu Grid: Set Grid: 1 cm or similar, Cartesian, Snap to grid
- 4. Zoom in/out to cover your real bath
- 5. Use (1) to draw important points (like vortices), (2) for lines connecting points and (3) for arches connecting points
- 6. Menu Properties/Materials Add material „Air“, permittivity = 1
- 7. Menu Properties/Boundary Add 2 boundary conditions: Ground (Fixed voltage of 0V) and Voltage (Fixed voltage of 1V)

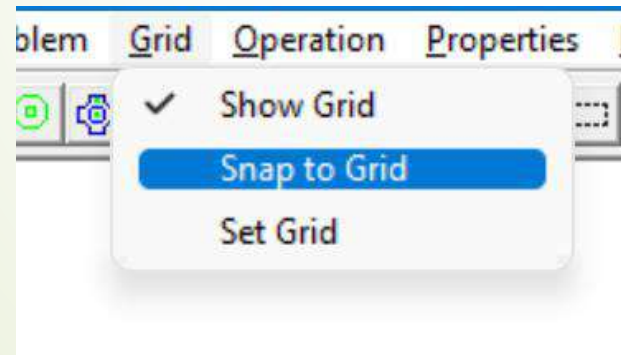
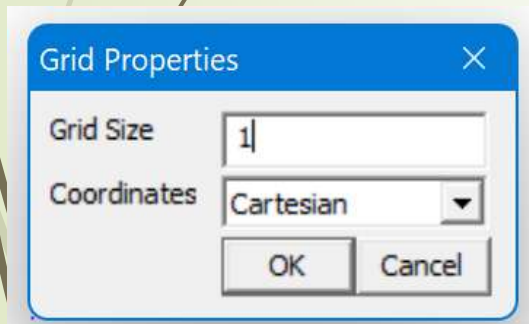
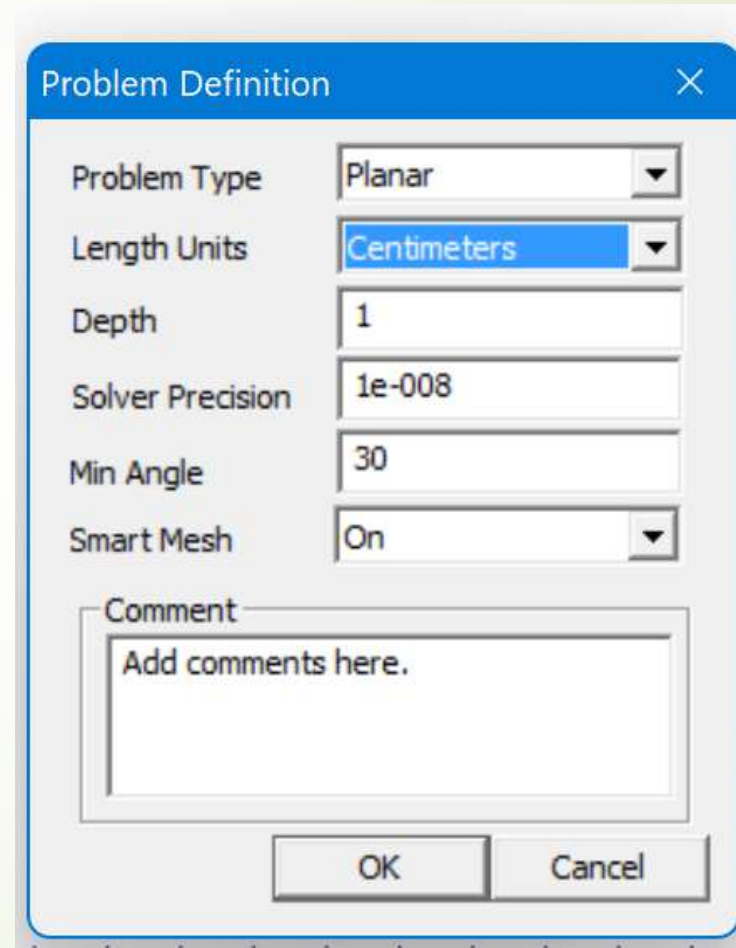
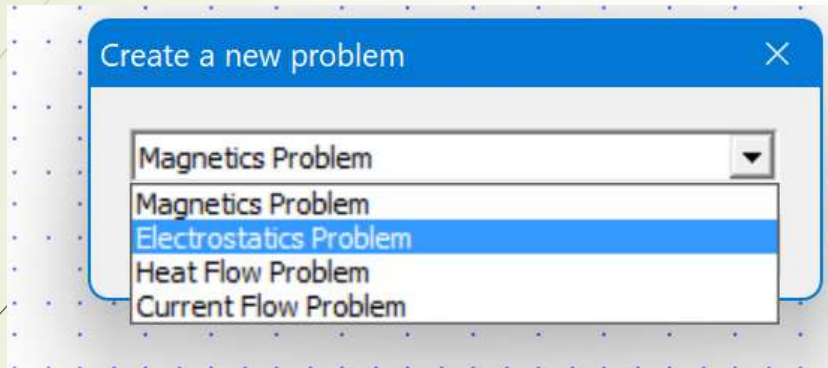


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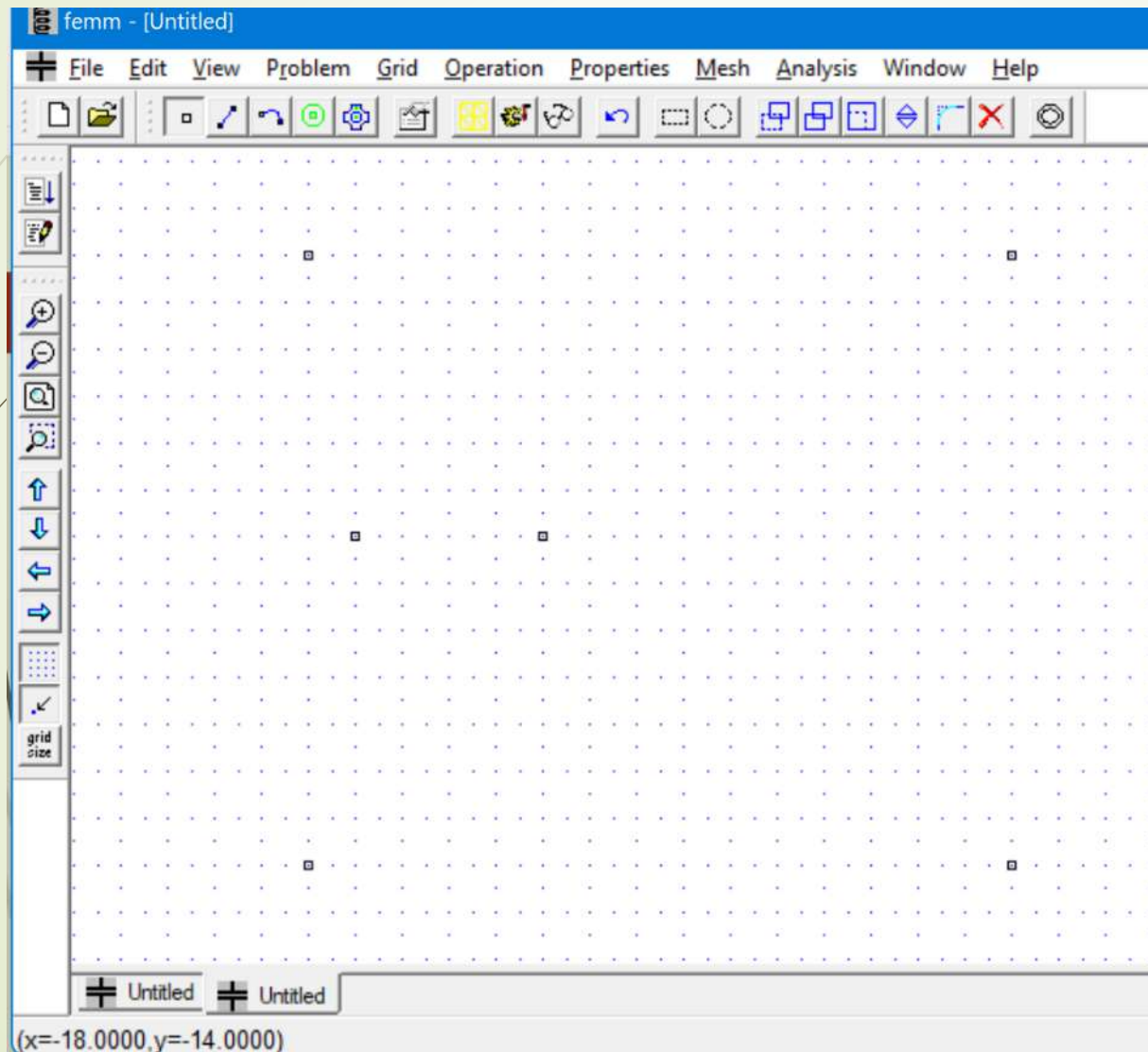
Equipotential Lines - FEMM

- 8. Select (4) and click into the „water“ area. Right klick label <none>, use (5) and select „Air“ material.
- 9. Select (4) and click into the electrode area. Right klick label <none>, use (5) and select <No Mesh> (field will not be calculated in the electrode).
- 10. Save your project.
- 11. Use (6) to generate mesh (points where the field will be calculated)
- 12. Use (7) to calculate the field
- 13. (Use (8) to view results

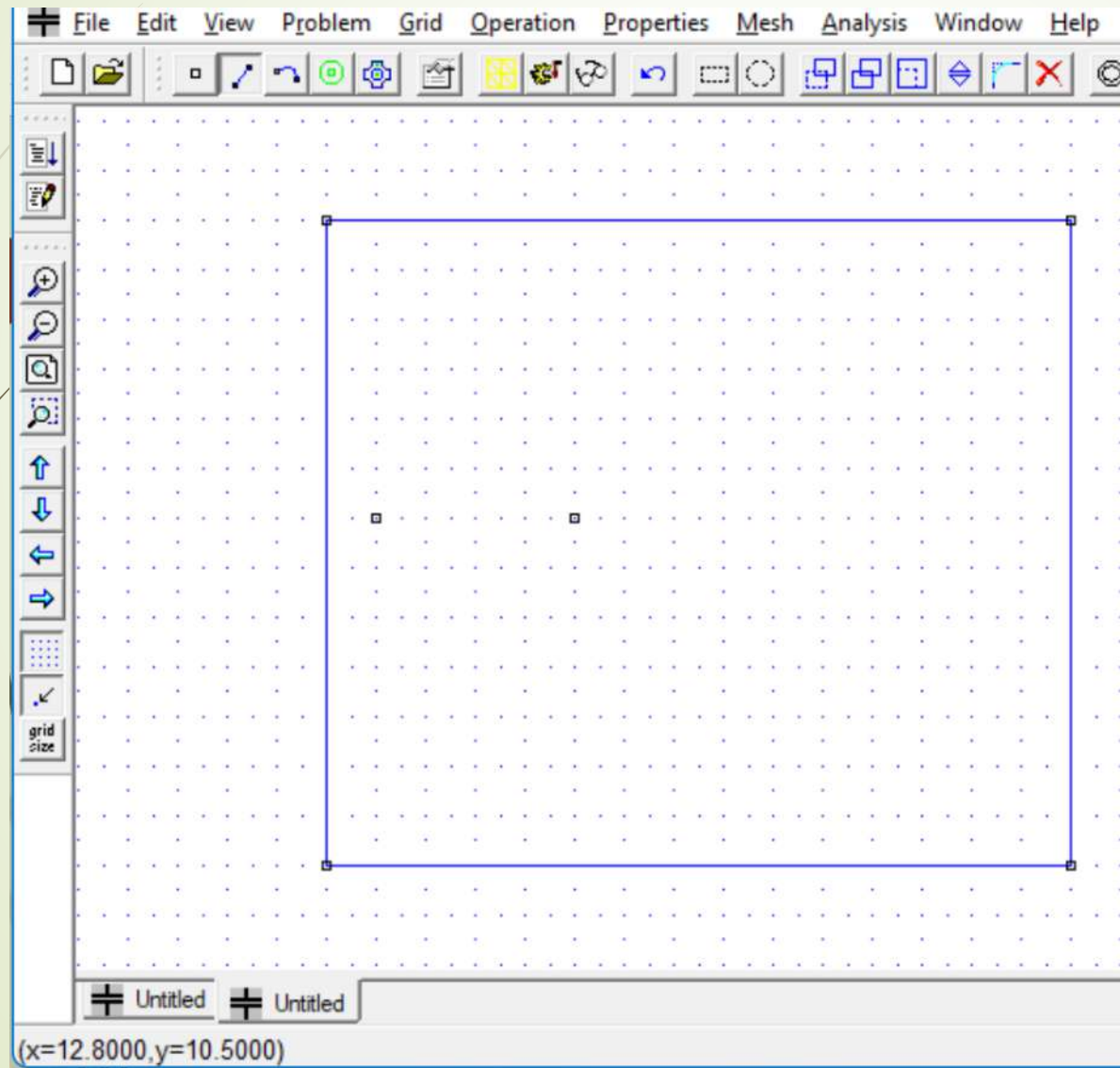
Equipotential Lines - FEMM



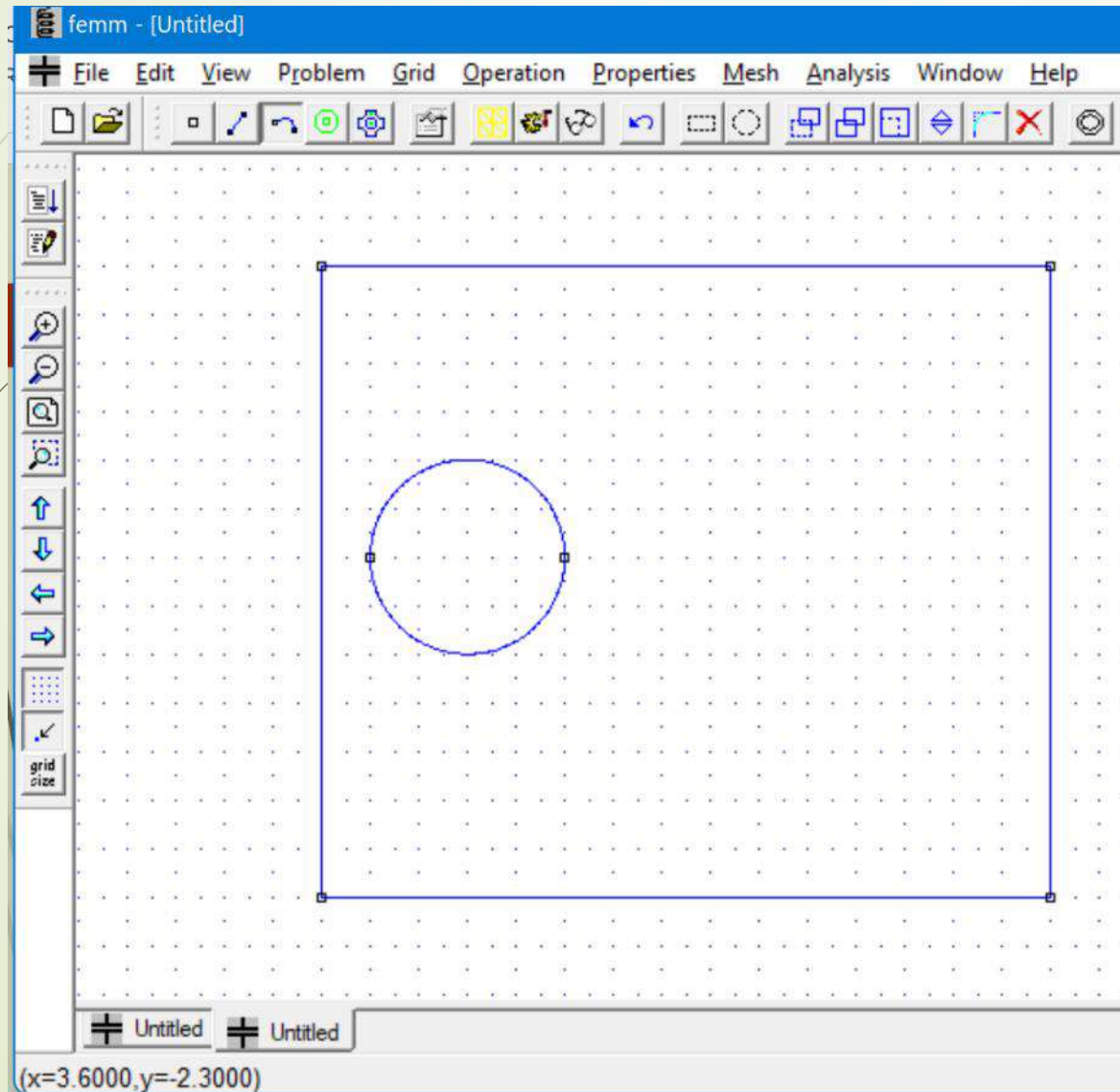
Equipotential Lines - FEMM



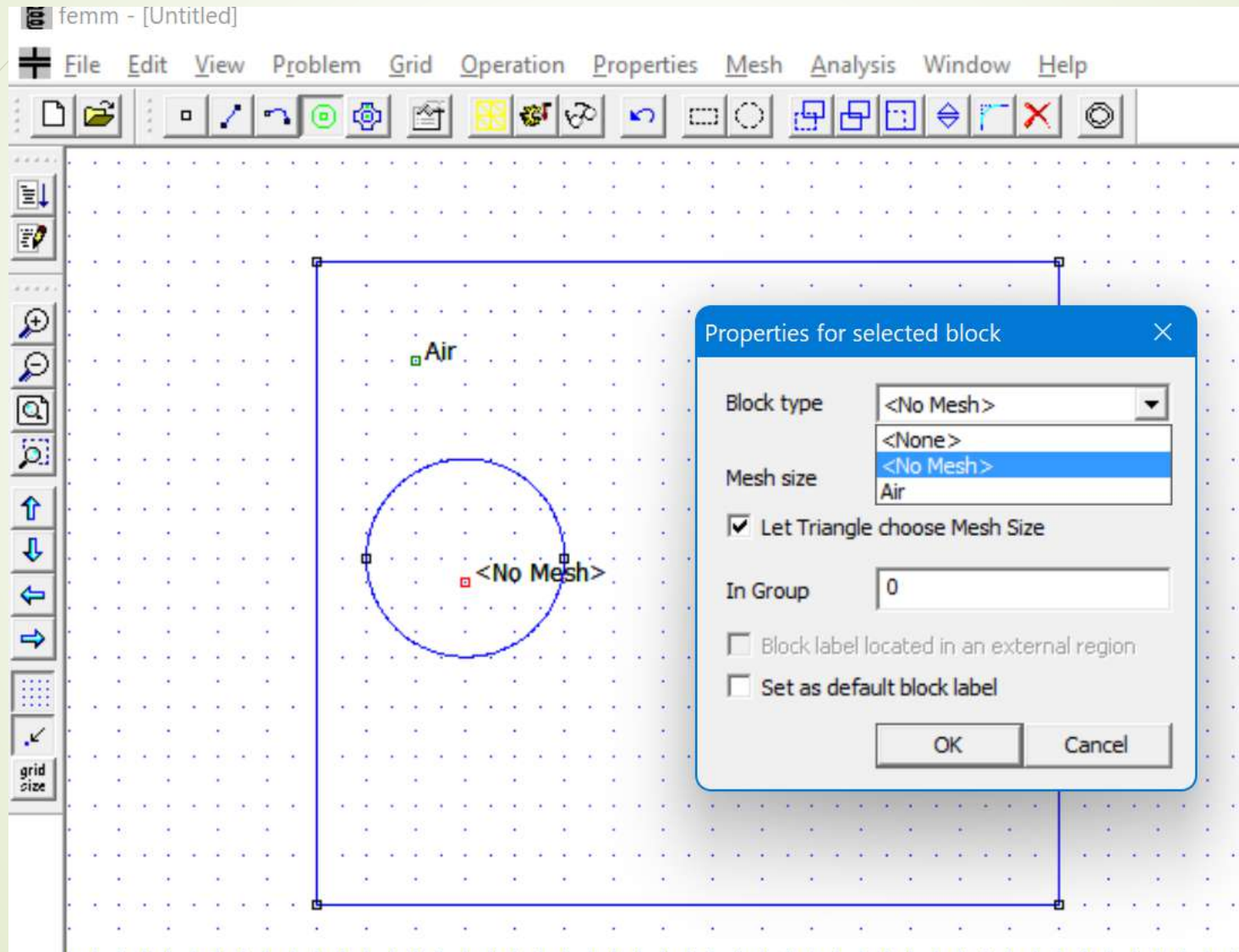
Equipotential Lines - FEMM



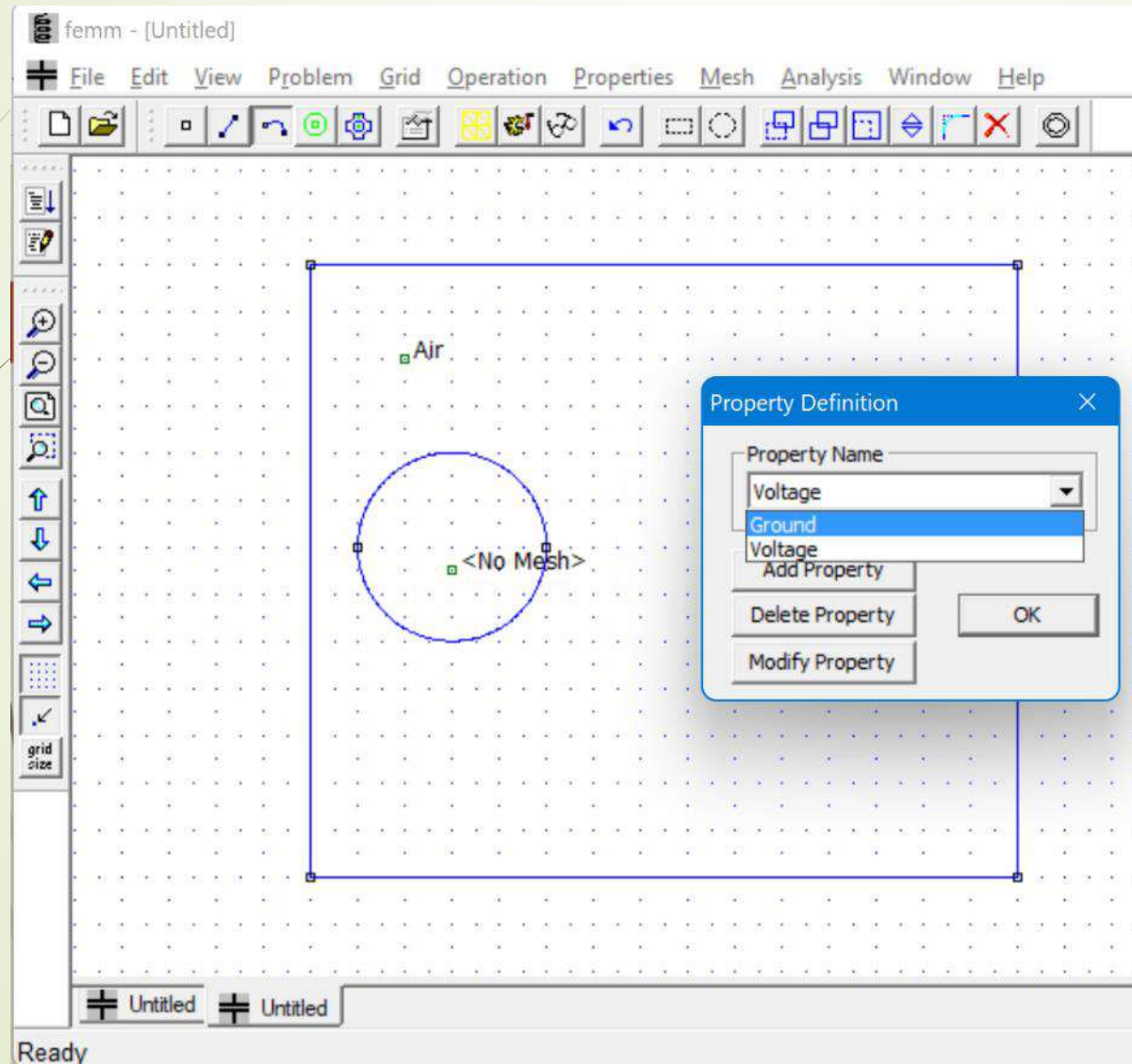
Equipotential Lines - FEMM



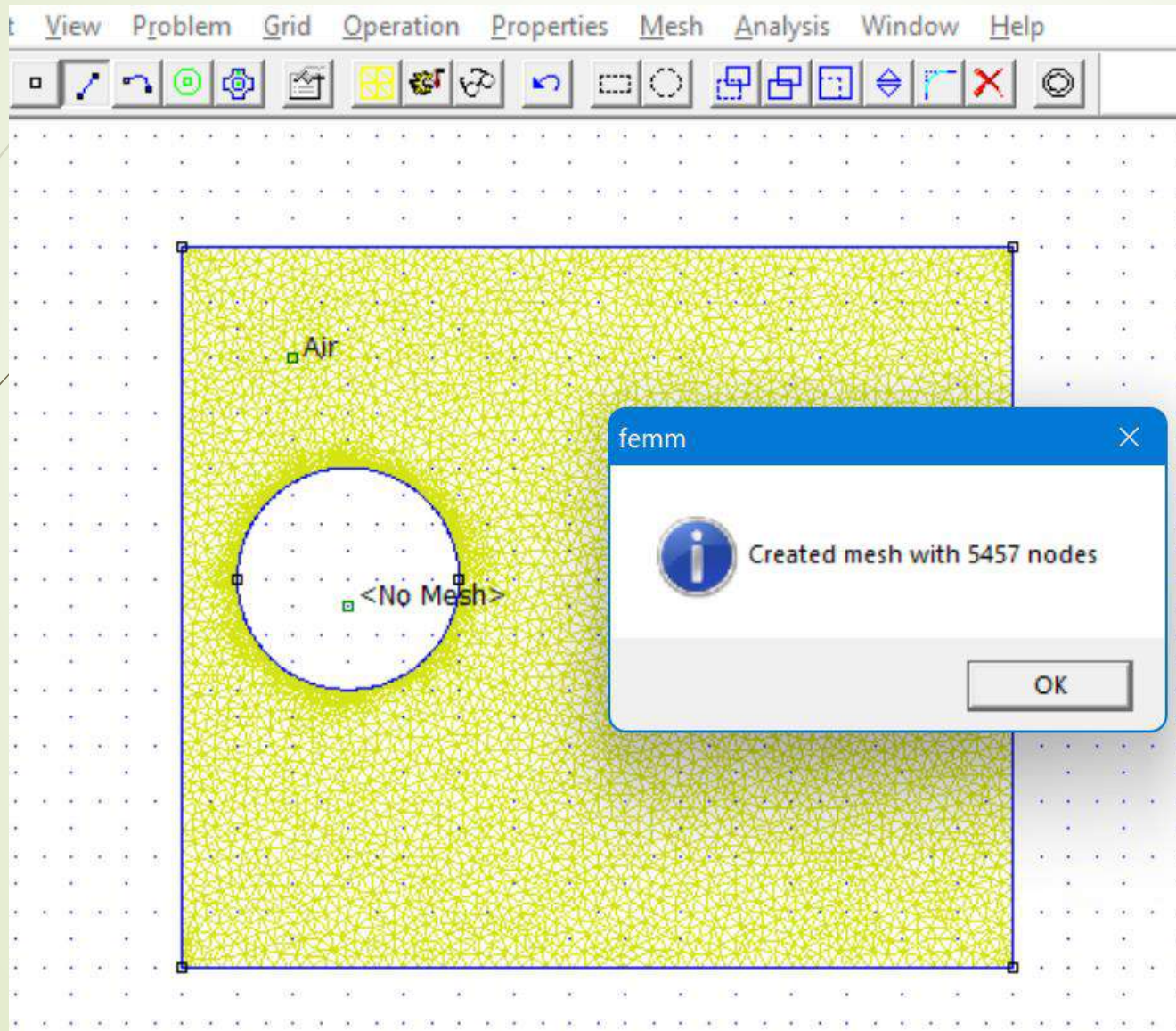
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