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8. Equipotential Lines

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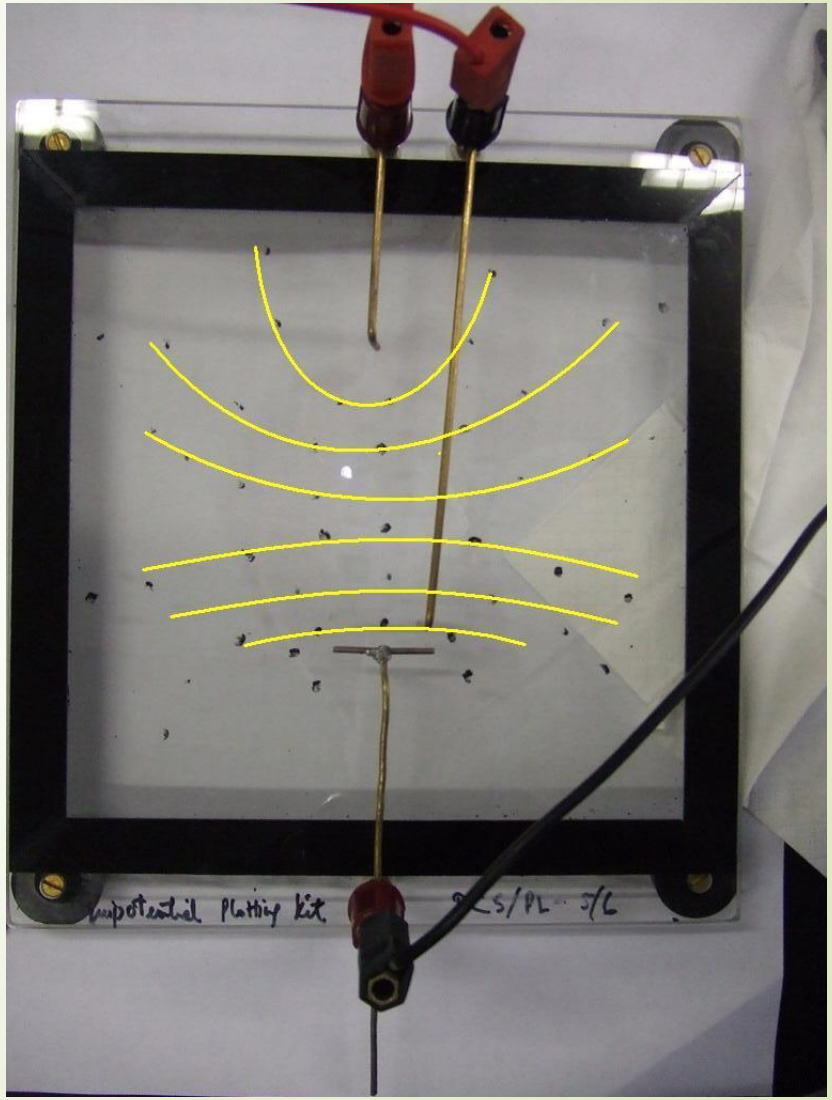
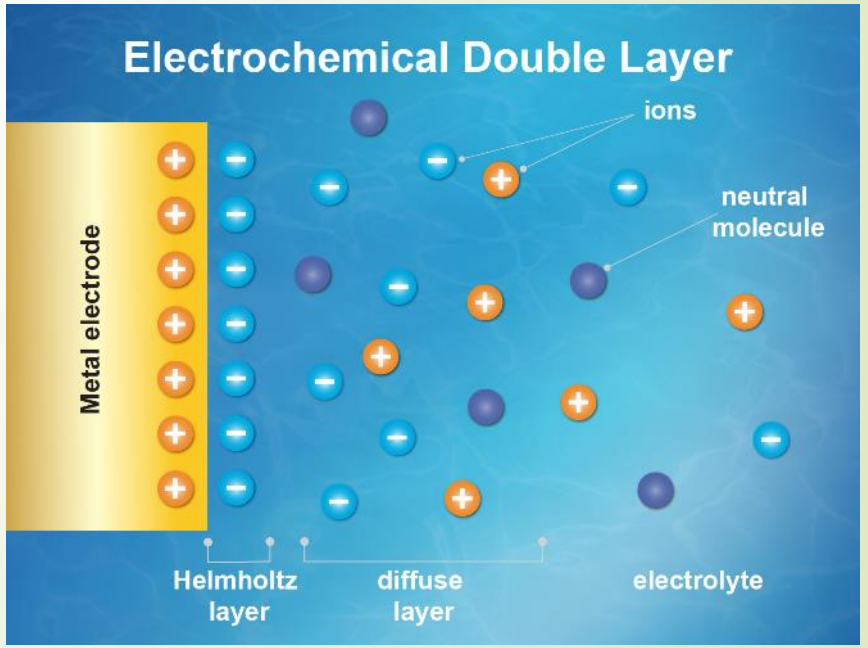
8. Equipotential Lines

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

- Metalic 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 (destiled water, salty water, ...)
  - Frequency of the AC voltage (~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

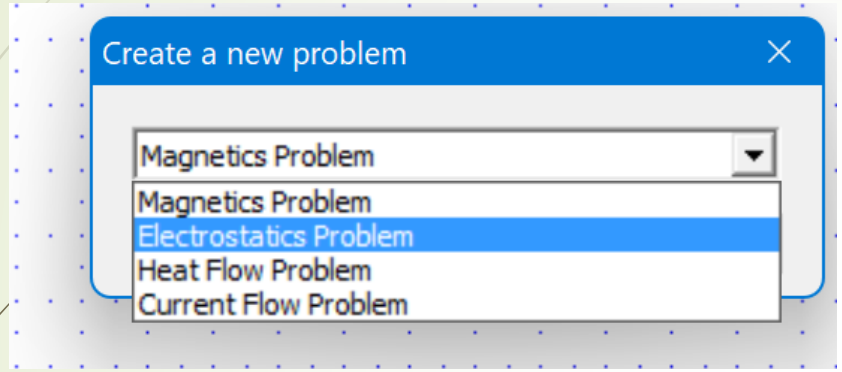
Equipotential Lines - FEMM

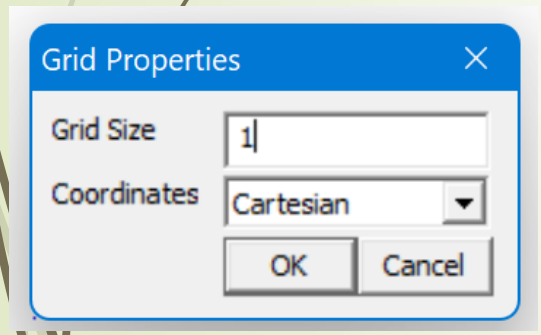
- 1. Start FEMM, File/New/Electrostatic problem
- 2. Menu Problem: set planar problem, units to cm or mm
- 3. Menu Grid: Set Grid: 1 cm or similar, Cartesian, Snap to grid
- 4. Zoom in/out to cover your real bath
- 5. Use (1) to draw important points (like vortices), (2) for lines connecting points and (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)

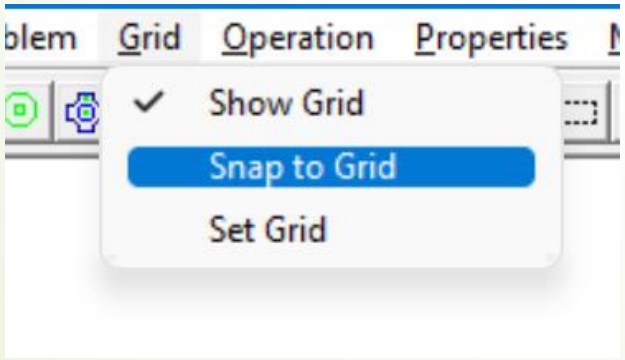
Equipotential Lines - FEMM

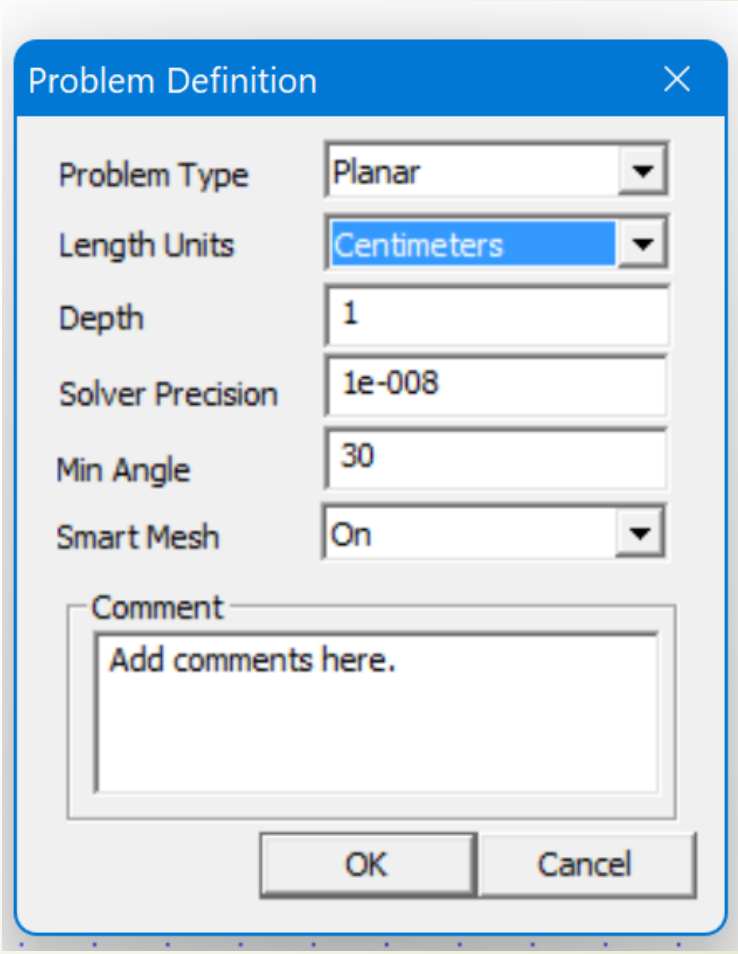
- 8. Select (4) and click into the „water“ area. Right klick label <none>, use (5) and select „Air“ material.
- 9. Select (4) and click into the electrode area. Right klick label <none>, use (5) and select <No Mesh> (field will not be calculated in the electrode.
- 10. Save your project.
- 11. Use (6)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









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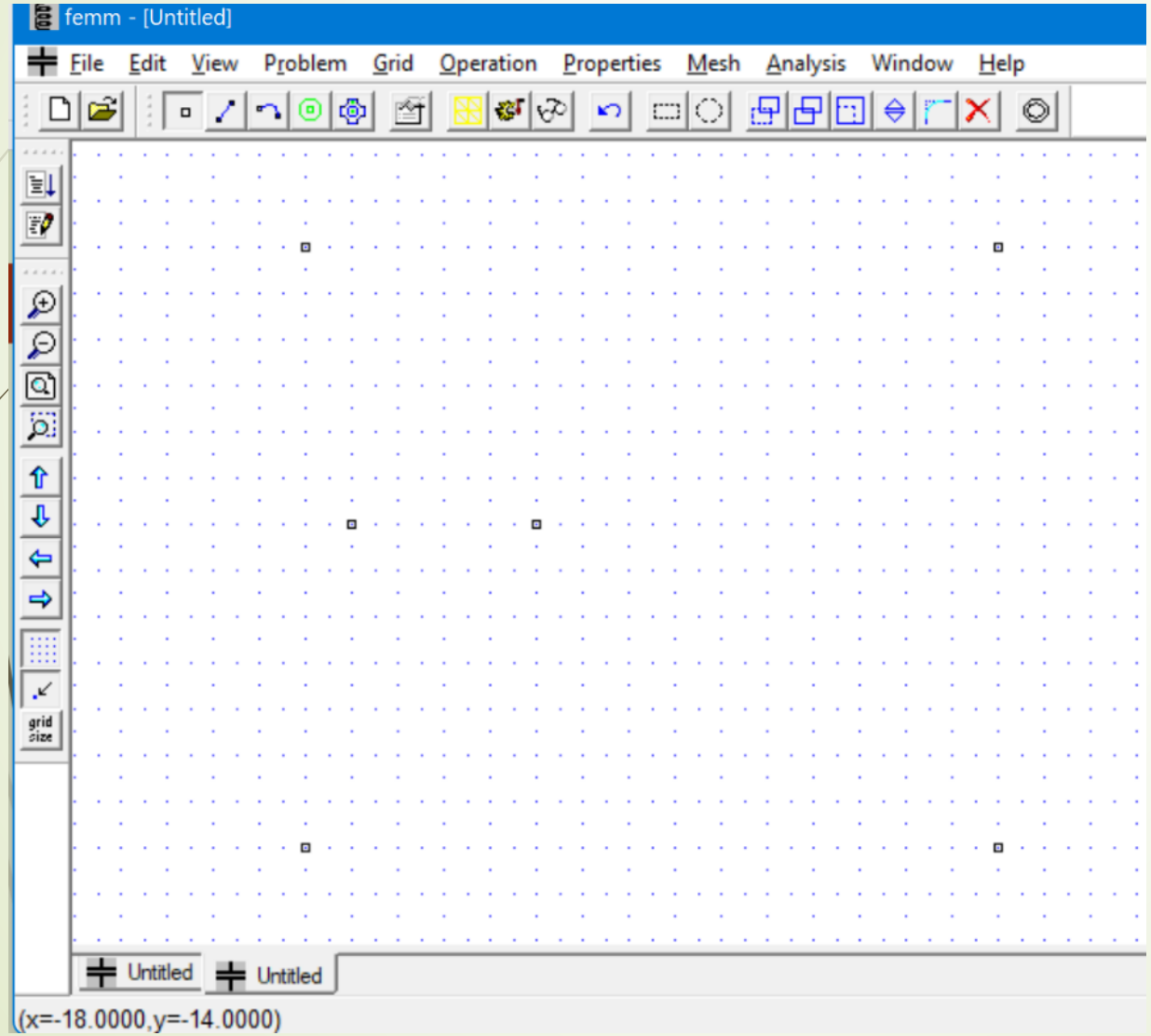

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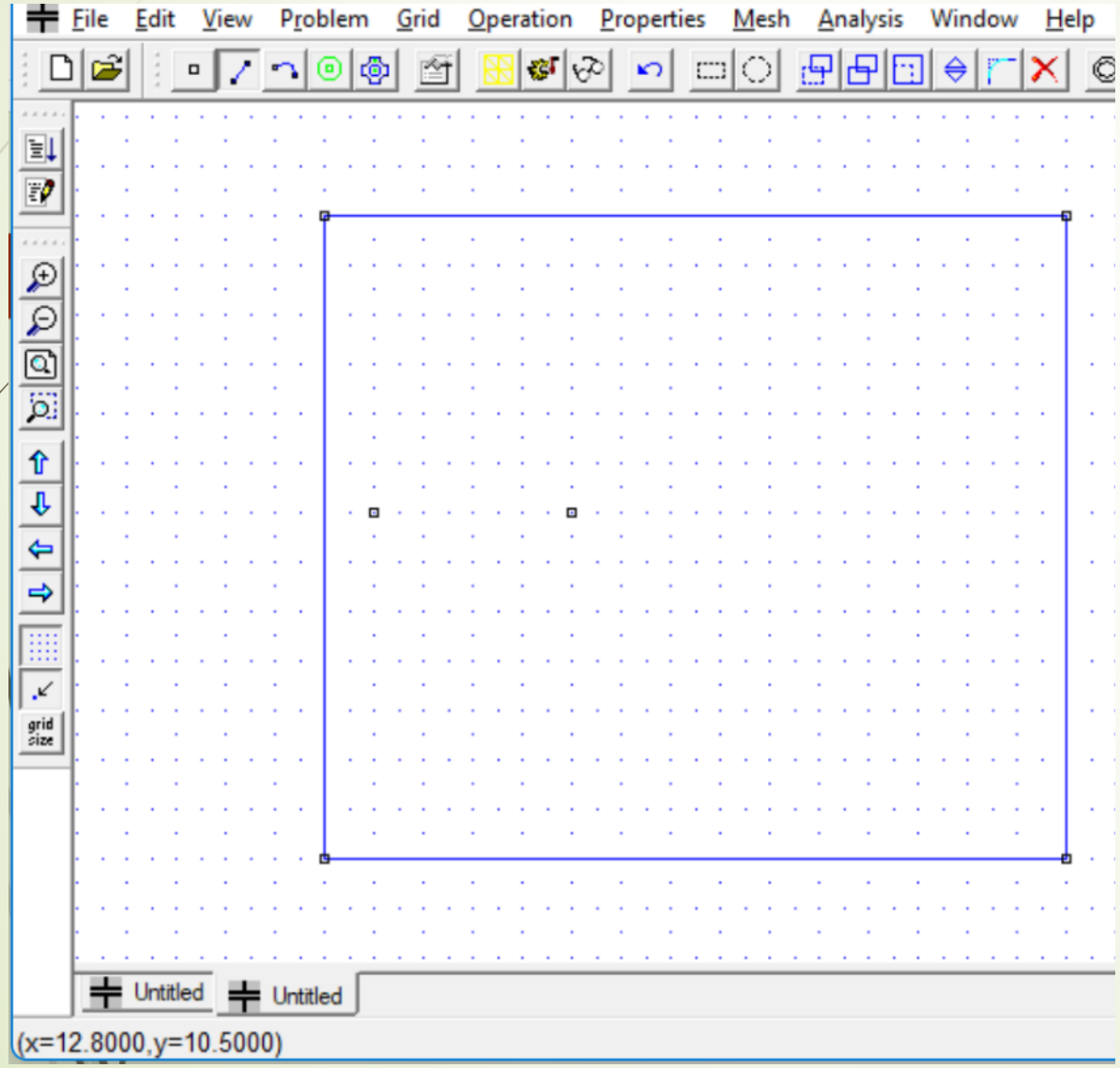

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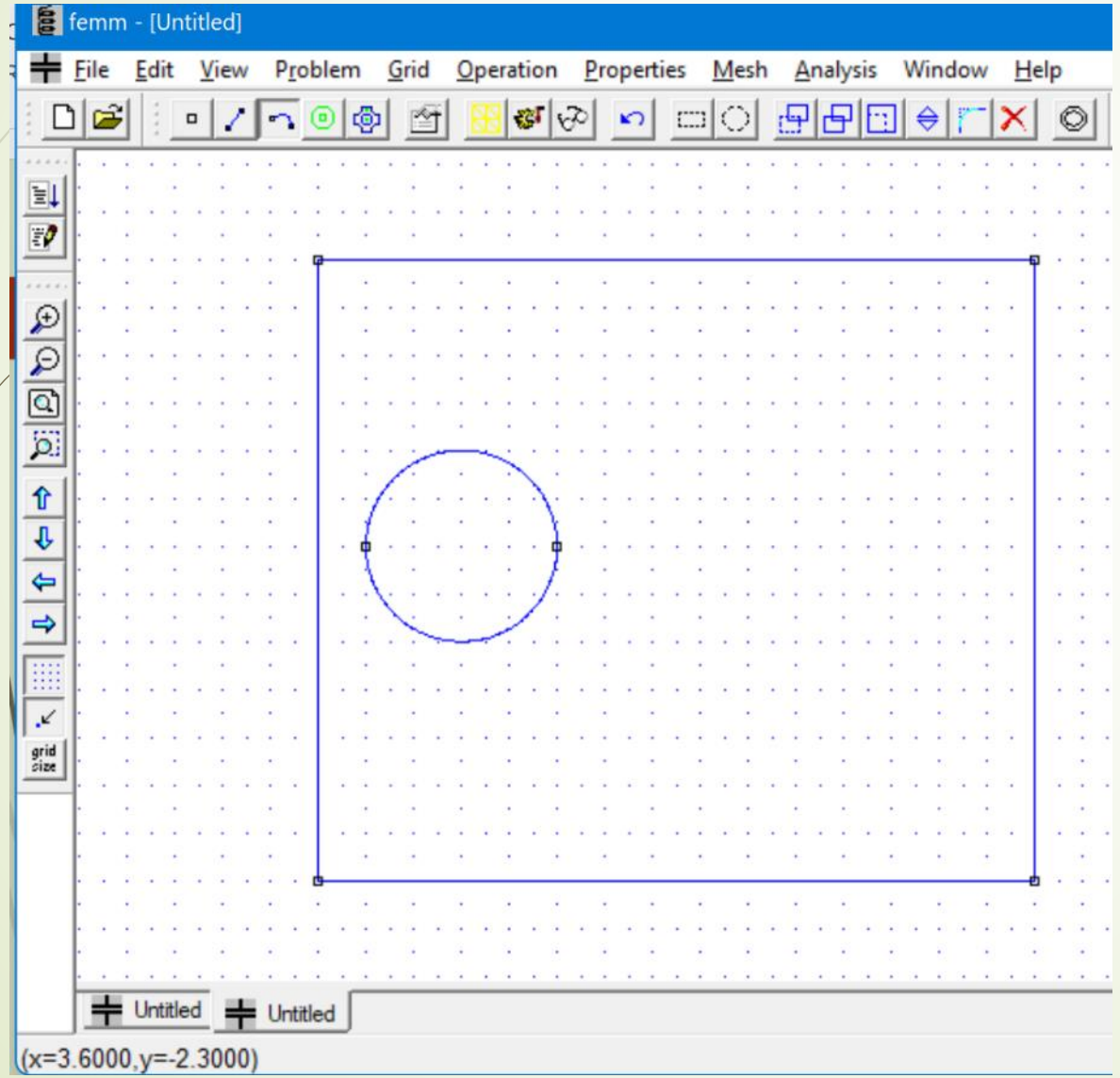

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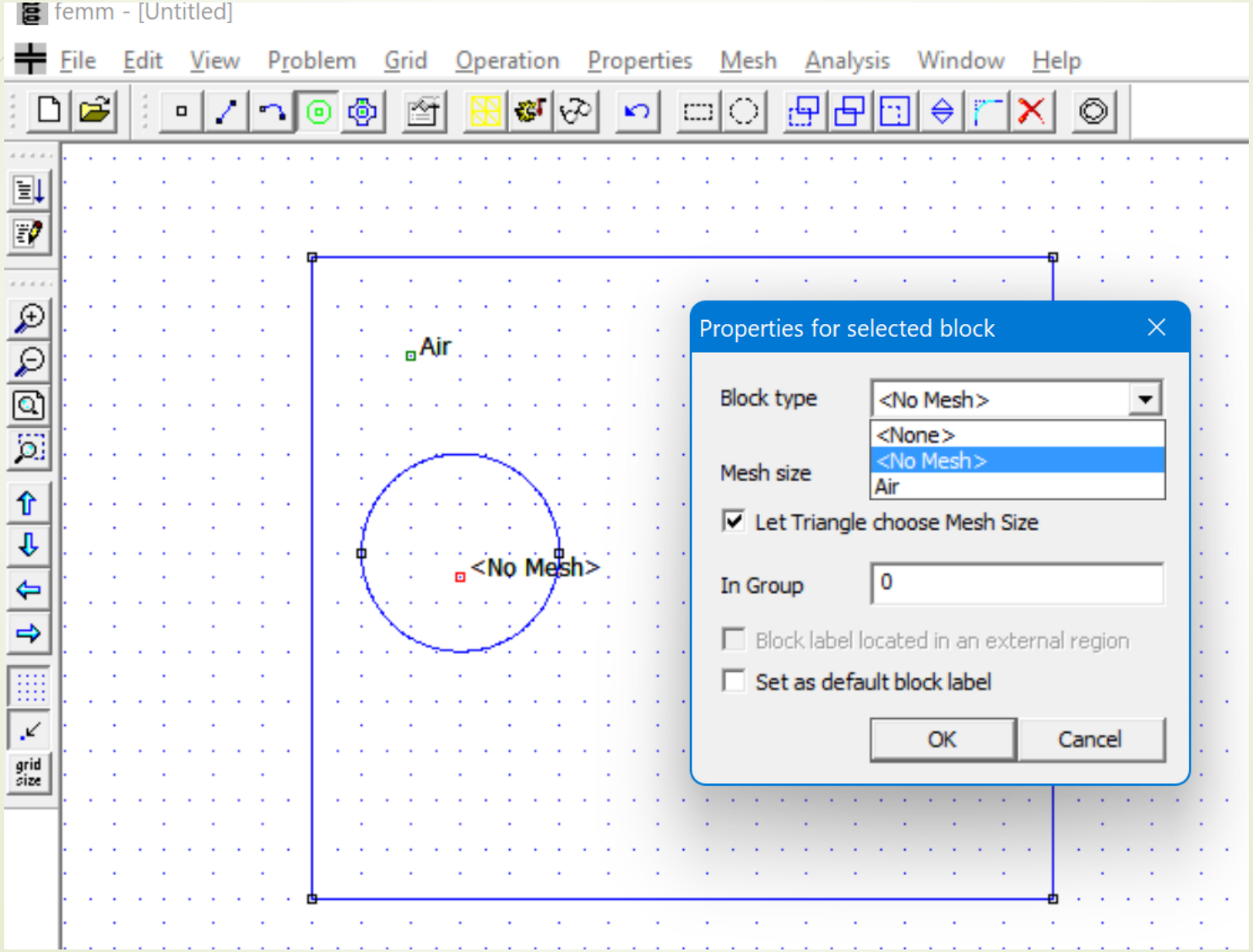

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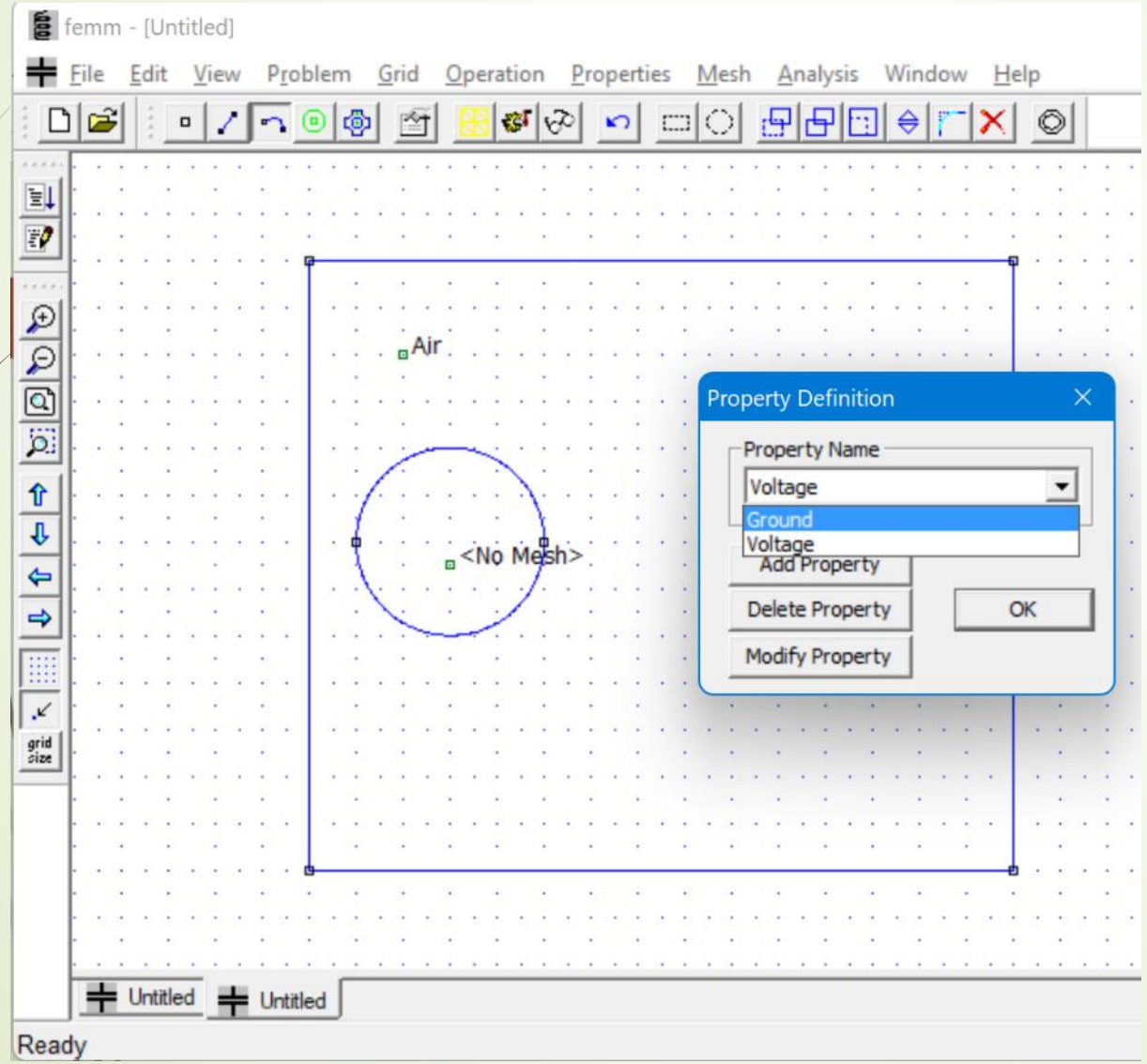

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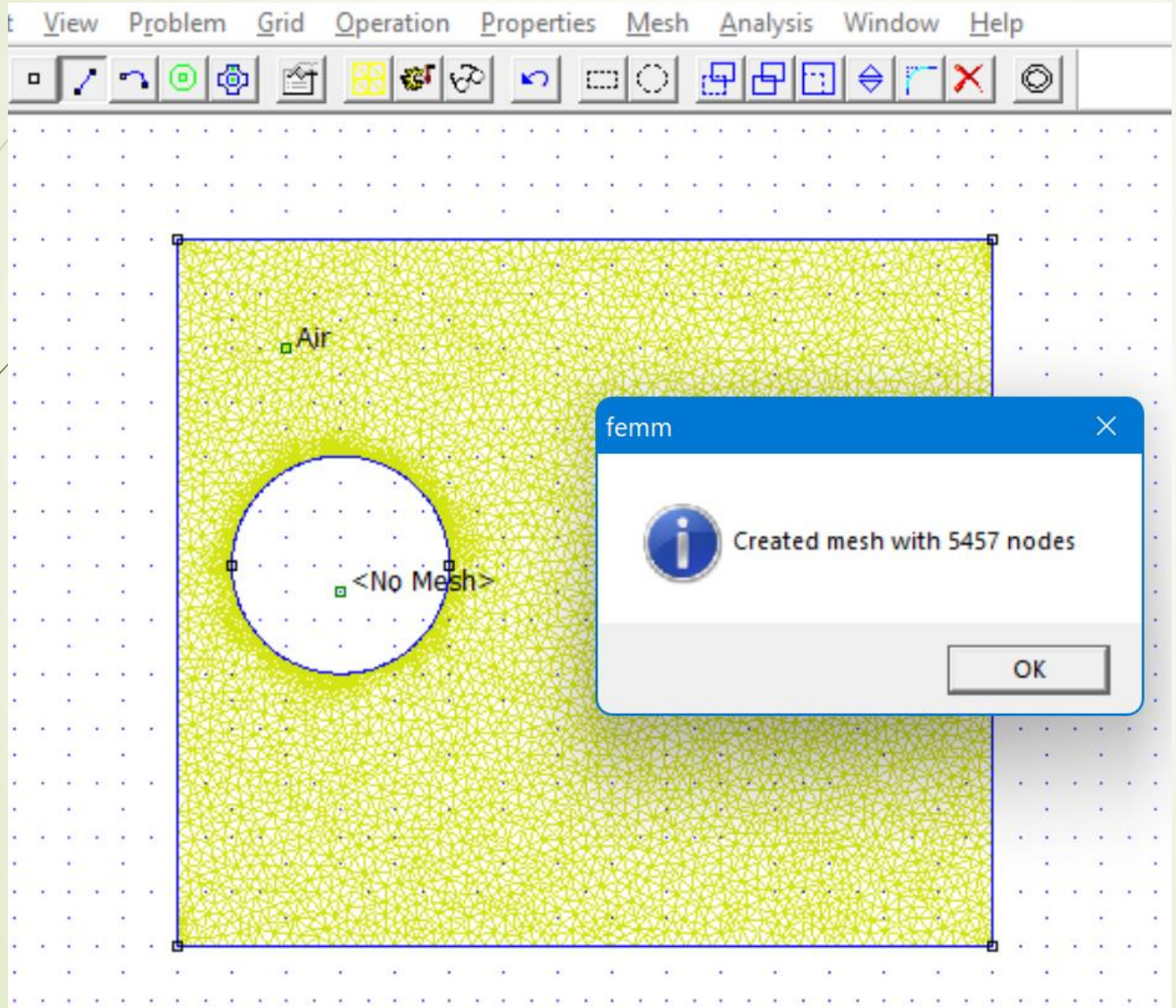

Equipotential Lines - FEMM