Engy-4350: Nuclear Reactor Engineering Spring 2019 UMass Lowell; Prof. V. F. de Almeida
**04Mar19**

# Midterm Exam 04-06 Mar 2019

## Name:

## Guidance:

- This is an open-book, open-note, **individual** exam.
- No discussion with anyone is allowed.
- You may use online documents and course notes.
- Make sure to answer the questions asked.
- Show your **invidual** work and be crystal clear.

## Rubric Panel

| Show No. | Now Showing (2:00-3:15pm) | Value | Score |
|---|---|---|---|
| 1 | For a Lifetime | 50 | |
| 2 | Sudden Insertion Current | 50 | |
| - | Total | 100 | |

---

## Table of Contents

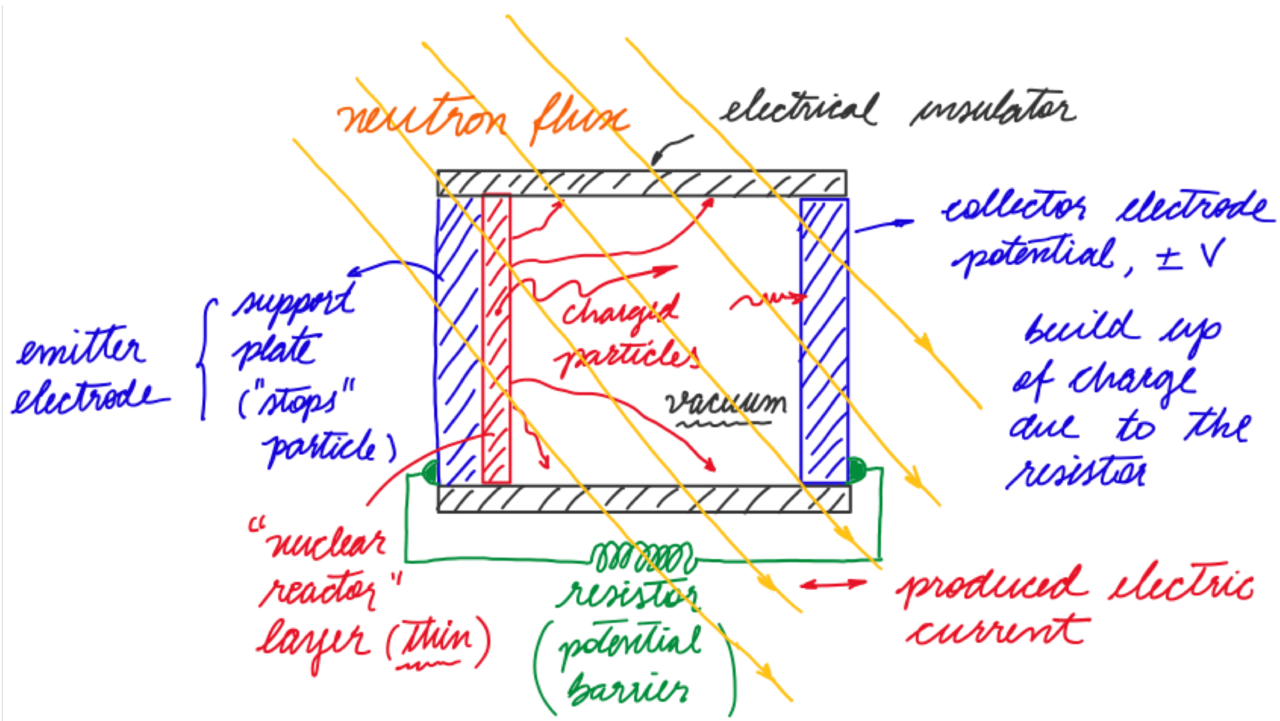

- Show Problem 1 (50 pts)
- Show Problem 2 (50 pts)


---

## Show Problem 1 (50 pts)

Consider a **fission-electric cell**, constructed with a thin layer of $^{235}$U, pure metal (mass density 19.1 g/cm$^3$), as shown in the diagram below. The cell is inserted in a nuclear reactor where a constant thermal neutron flux exists where: $\varphi = 10^{14}\,\frac{\text{neutrons}}{\text{cm}^2\ \text{s}}$. **Use nuclear data from the NNDC or any other of the nuclear data sites referred to in course notes.** Assume the data is for temperature of 20 C.

1. Explain why there is an electric current in the external circuit? Be very clear.
2. Why is the electric current in the external circuit time-dependent?
3. Provide a formula that computes the time-dependent electric current $J(t)$.
4. Compute the mean lifetime $\tau$ of the fission-electric cell.
5. If the temperature of the cell is 300 C, what is the new current and what is the new lifetime of the cell?
6. What needs to be done if this cell is used to measure the constant neutron flux?




1.1: Explain why there is an electric current in the external circuit? Be very clear.

1.2: Why is the electric current in the external circuit time-dependent?

1.3: Provide a formula that computes the time-dependent electric current $J(t)$.

1.4: Compute the mean lifetime $\tau$ of the fission-electric cell.

1.5: If the temperature of the cell is 300 C, what is the new current and what is the new lifetime of the cell?

1.6: What needs to be done if this cell is used to measure the constant neutron flux? Explain and give a mathematical answer.

## Show Problem 2 (50 pts)

In Problem 1, the reactor is under a start-up condition where a source is suddenly inserted. The source strength is $q_0 = 10^8 \frac{\text{neutrons}}{\text{cm}^3 \text{ s}}$ and a negligible amount of neutron density was initially in the reactor at start-up condition. Using a point-reactor model with 6-group delayed-neutron emission precursor species,

1. Use the model asymptotic limit of the neutron flux response in the reactor to re-derive the time-dependent electric current on the external circuit of Problem 1.
2. Calculate the time needed for the reactor to reach its nominal power condition of $\varphi = 10^{14} \frac{\text{neutrons}}{\text{cm}^2 \text{ s}}$.
3. If the electric current is measured during this start-up condition, how could you compute the neutron generation time in the reactor?

2.1: Use the model asymptotic limit of the neutron flux response in the reactor to re-derive the time-dependent electric current on the external circuit of Problem 1.

2.2: Calculate the time needed for the reactor to reach its nominal power condition of $\varphi = 10^{14}\ \frac{\text{neutrons}}{\text{cm}^2\ \text{s}}$.

2.3: If the electric current is measured during this start-up condition, how could you compute the neutron generation time in the reactor?