Ideas for Projects

1. a) Develop event sequence diagrams for ACR-700 or ACR-1000 for the following initiating events: I) Loss of main feedwater flow; ii) small LOCA; iii) large LOCA; then b) Suppose an ACR-700 or -1000 has a LOCA + LOECC + loss of moderator cooling. Calculate the demand availability of the Reserve Water makeup to the moderator. You will need the technical description of the ACR-700 or -1000 (look on the USNRC Web site for the ACR-700, or the UK HSE submission for the ACR-1000 Technical Description - you may need to ask AECL for this formerly public report).

2. Assume a partial flow blockage in a CANDU fuel channel (your choice which CANDU and which channel). a) Calculate the pressure tube temperature near the channel exit for a range of *steady-state* flow reductions. c) What percentage reduction of the flow is required for the pressure tube to fail (assuming steady-state)? Justify this in terms of pressure-tube behaviour at high temperatures. d) Using the simple fuel model described in the lecture notes (or develop your own), and a reasonable value for the steam cooling sheath-to-coolant heat transfer coefficient, calculate the *steady-state* flow that will just lead to central melting of the fuel rod. (You will need to make simplifying assumptions on the channel and bundle power distributions). e) What conclusions can you draw from these answers re the likelihood of fuel melting before pressure-tube failure?

3. Consider an uncontrolled severe core damage accident in a CANDU (not ACR) resulting from loss of all heat sinks. Develop and describe the sequence of events up to failure of the shield tank or reactor vault and calculate (by hand, or write your own code) the (very) approximate timing of each major event. Include containment behaviour. *Hint: Use energy balances.*

4. Compare a large LOCA and a main steam line break inside containment. Use a CANDU safety report and develop a list of symptoms which the operator can see; use them to show how he can determine the accident that has occurred and what he should do. You will need to understand what signals are available and roughly how they would behave. Compare the symptoms and signals for a CANDU with a positive void coefficient with that for an ACR with a small negative void coefficient, and with that for a PWR.

5. From the report OH 84083 and other available reports, examine the accident that occurred in Pickering A Unit 2 in August 1983. Determine the immediate cause, evaluate the operating steps taken by staff, and derive the root causes of the event using formal methods. Considering the plant conditions as they unfolded during the event, determine the reasons and timing for each operating step. Evaluate the accident in terms of design and safety culture. (Note that a simple summary of existing reports is not acceptable).

6. Using the diagram of the SDS1 trip logic in the overheads in Chapter 4, Lecture 4 of your handouts, construct and evaluate the fault tree for initiation of a reactor trip on any one signal. Include all system components from the sensor signal to the clutch release. Estimate probabilities of each component and give the reasons for your estimates.

7. Calculate the design pressure of the ACR-1000 containment building, from scratch. You will need to calculate the steam discharge rate and enthalpy after a main steam line break. Obtain ACR-1000 data as per Project 1.

8. Develop a thermohydraulic model of the McMaster Nuclear Reactor circuit. Use it to calculate the reactor behaviour following a beam tube break. (Do not use models that have already been developed). If the break is not isolated, calculate the fuel temperature when the core is uncovered.

9. Develop a reactor physics model of the McMaster Nuclear Reactor. Use it to calculate the reactor behaviour following a loss of reactivity control accident. Include shutdown system models. (Do not use models that have already been developed).

10. Assume a flow blockage of a fuel assembly in the McMaster Nuclear Reactor. Develop a model to calculate the transient heatup.

11. Assemble all the information you can find on the 2006 incident in the Forsmark station in Sweden (common mode failure of backup power supplies). Analyse the accident (using a root cause technique, for example) in terms of defence in depth, operator response, and common mode design/operation errors.

12. A CANDU station is trying to decide whether or not to put in filtered containment venting for severe accident (assume loss of all on-site AC power). Develop the cost/benefit case to help them make this decision. You will need to calculate or research the severe accident consequences in terms of health effects and economic loss, the reduction in severe accident frequency and/or consequences from the filtered venting, and the cost of the back-fit in terms of money and radiation exposure. As an optional extra, compare that design solution to others such as adding redundant/diverse AC diesel-generators. You can choose either a multi-unit vacuum station or a single-unit CANDU (the accident behaviour and time-scales are somewhat different)

13. Assemble all the information you can find on the numerous incidents in Japan, between 1978 and 2000, of inadvertent criticality in BWRs. Analyse one of the accidents (using a root cause technique, for example) in terms of defence in depth, operator response, and

design/operator interaction. Discuss if the accidents reveal any weaknesses in the BWR design. Discuss the lack of reporting of these accidents (until recently) in terms of safety culture.

14. Compare catastrophic accident in nuclear power with those in other energy industries. Consider both real and potential accidents, and discuss such aspects as cost, health effects, environmental effects, psychological effects, and probability.

15. Discuss the impact of the CNSC design requirements for new nuclear power plants (RD-337) if applied to an existing CANDU reactor. Perform a rough cost-benefit analysis of any changes identified.

16. Compare and contrast the safety characteristics of LWRs and CANDU (or ACR-1000). Develop the comparison in depth and do not copy existing studies - although you can use them for basic ideas.

17. ...or any other project requiring similar levels of originality and of similar difficulty. You will need my prior agreement.