NPRE 402
Nuclear Power Engineering
Spring 2023

Online Temporary Alternative Coverage and access during Covid-19 Pandemic and possible resurgence through mutations and variants

1. Please read the assigned-reading lecture-notes chapters.
2. Then answer the corresponding written assignment,
3. For questions about the assignments, please access the teaching assistants by email:
https://www.mragheb.com/NPRE%20402%20ME%20405%20Nuclear%20Power%20Engineering/talist.htm
4. Submit the corresponding written assignment through email to https://canvas.illinois.edu
5. Please use either the Word or pdf formats
6. In case of internet "rationing" (e. g. to health and government authorities), instability, or collapse through overload, please read the lecture notes and submit the corresponding assignments. Already-taken tests and submitted assignments would be used in assessing the final grade.

Regrettably, some 3,278 colleges and universities across the USA have been impacted by the Covid-19 pandemic, with many temporarily closing their campuses and switching to online classes, affecting more than 22 million students.

To all and everyone we wish good health and well-being.

Threat of Nuclear War:
https://www.youtube.com/watch?v=HSC7Lp1nvx8
https://www.youtube.com/watch?v=M7hOpT0lPGI

Number	Date Assigned	Due Date	Description
1	1/18	1/25	**Reading assignment** **Preface** **Written Assignment** In Greek mythology, who is Artemis' brother? Who was born first? https://en.wikipedia.org/wiki/Artemis_program Write a paragraph about the "Fermi Paradox". Define the Terawatt unit of power. Access the internet to determine the latest available figure of total global power consumption. Use the Carl Sagan's formula to calculate our technological civilization's level on the Kardashev's cosmic scale. On the Kardashev Scale, identify the power needs in Watts for Type I, II and III civilizations. In how many years is our Earth expected to achieve a Type I status?
2	1/20	1/27	**Reading assignment** **Preface** **Written Assignment** Define the Quad unit of energy in terms of BTUs and Joules. Compare the primary energy sources in the 2019 LLNL Sankey Diagram to the 2025 predicted one. Use the 2019 Sankey diagram to calculate the end use efficiencies of the following energy sectors:

			1. Residential, 2. Commercial, 3. Industrial, 4. Transportation. What is the percentage share of nuclear energy in: a) The primary energy supply, b) Electrical energy generation?
3	1/23	1/30	**Reading assignment** **1. First Human Made Reactor and Birth of Nuclear Age** **Written Assignment** Compare the power level of the CP1 reactor to that of a typical nuclear power plant. What was the moderator, control rods and fuel materials used in the CP1 reactor? Data mine the Chart of the Nuclides for the following information on elements used in nuclear applications: 1. *Naturally* occurring isotopes and their natural abundances. 2. Atomic masses of isotopes in atomic mass units (amu). for the following elements: a) Uranium (U). b) Thorium (Th). c) Carbon (C). d) Hydrogen (H). e) Lead (Pb). f) Beryllium (Be). g) Lithium (Li). h) Sodium (Na). i) Boron (B). j) Cadmium (Cd). k) Fluorine (F)
4	1/25	2/1	**Reading assignment** **1. First Human Made Reactor and Birth of Nuclear Age** **Written Assignment** i) Calculate the speed in meters per second of neutrons possessing the following energies: a. Fast neutrons from fission at 2 MeV, b. Intermediate energy neutrons at 10 keV, c. Thermal energy neutrons at 0.025 eV. What is the half-life in minutes of a free unbound neutron? What does it decay into? Hint: Access the Chart of the nuclides.
5	1/27	2/3	**Reading assignment** **1. First Human Made Reactor and Birth of Nuclear Age** **Written Assignment** Apply conservation of charge and of nucleons to balance the following fissile breeding reaction:

			$_0n^1 + {}_{92}U^{238} \rightarrow {}_{92}U^{?}$ $_{92}U^{?} \rightarrow {}_{-1}e^0 + {}_{?}?^{?}$ $_{?}?^{?} \rightarrow {}_{-1}e^0 + {}_{?}?^{?}$ $- - - - - - - - - - - - - - -$ $_0n^1 + {}_{92}U^{238} \rightarrow 2\,{}_{-1}e^0 + {}_{?}?^{?}$ If a single fission reaction produces about 180 MeV of energy, use Avogadro's law to calculate the number of grams of the fissile elements: 1. U^{235} 2. Pu^{239} 3. U^{233} 4. Np^{237} that would release 1 kT of TNT equivalent of energy. Assume that all the energy release is available, except for the energy carried away by the antineutrinos, as well as the delayed fission products beta particles and gamma rays, which is not fully recoverable. Hint: Use Avogadro's law to estimate the number of nuclei in a given weight of the fissile material: $N[nuclei] = \frac{g[gm]}{M[amu]} A_v, \quad A_v = 0.6 \times 10^{24} [\frac{nuclei}{mole}]$
6	1/30	2/6	**Reading assignment** **4. Nuclear World** **Written Assignment** Apply conservation of charge and nucleons to balance the following nuclear reactions: 1. $_1D^2 + {}_1T^3 \rightarrow {}_0n^1 + ?$ (DT fusion reaction) 2. $_1D^2 + {}_1D^2 \rightarrow {}_1H^1 + ?$ (Proton branch of the DD fusion reaction) 3. $_1D^2 + {}_1D^2 \rightarrow {}_0n^1 + ?$ (Neutron branch of the DD fusion reaction) 4. $_1D^2 + {}_2He^3 \rightarrow {}_2He^4 + ?$ (Aneutronic or neutronless DHe^3 reaction). 5. $_0n^1 + {}_3Li^6 \rightarrow ?+?$ (tritium breeding reaction) 6. $_0n^1 + {}_3Li^7 \rightarrow {}_0n^1 + ?+?$ (tritium breeding reaction) 7. $_1T^3 + {}_1T^3 \rightarrow 2\,{}_0n^1 + ?$ (neutron multiplier reaction) 8. $_0n^1 + {}_5B^{10} \rightarrow {}_2He^4 + ?$ (neutron absorption reaction)
7	2/1	1/8	**Reading assignment** **4. Nuclear World** **Written Assignment** An ICBM has an average speed of 18,566 miles/hour. Calculate its Mach Number M, considering that the speed of sound is 761.2 miles per hour. What do the following nuclear-related acronyms stand for? ICBM, ABM, MIRV, kT, MT,

			DU, HEU, NPT, MAD, TNT, SALT.
8	2/3	2/10	**Reading assignment** **4. Nuclear Processes, The Strong Force** **Written Assignment** As Thorium is four times more abundant than Uranium in the Earth's crust it offers a larger energy supply in the form of U^{233}. Apply conservation of charge and of nucleons to balance the following fissile breeding reaction: $_0n^1 + {}_{90}Th^{232} \rightarrow {}_{90}Th^{?}$ $_{90}Th^{?} \rightarrow {}_{-1}e^0 + {}_{?}?^{?}$ $_{?}?^{?} \rightarrow {}_{-1}e^0 + {}_{?}?^{?}$ $- - - - - - - - - - - - - - - -$ $_0n^1 + {}_{90}Th^{232} \rightarrow 2\,{}_{-1}e^0 + {}_{?}?^{?}$ Complete the following reaction leading to the production of Carbon^{14}, that exists in all living creatures, with a half-life of 5,730 years as an ongoing nuclear transformation from the neutrons originating from cosmic rays bombarding Nitrogen^{14} in the Earth's atmosphere: $_0n^1 + ? \rightarrow ? + {}_6C^{14}$ $_6C^{14} \rightarrow ? + {}_7N^{14}$ $- - - - - - - - -$ $_0n^1 \rightarrow ? + ?$ Combine the two equations for the energy of a mass m and the energy of radiation with a frequency υ and a wavelength λ: $E = mc^2\,[ergs]$ $E = h\nu = h\frac{c}{\lambda}$ to deduce the equation that establishes the equivalence of mass and radiation: $m = R\nu$ where: $R = \frac{h}{c^2} = 7.365864 \times 10^{-48}\ \frac{\text{erg.sec}^3}{\text{cm}^2}$ is a constant of nature.
9	2/6	2/13	

Assignments Policy

Assignments will be turned in at the beginning of the class period, one week from the day they are assigned.
They need to be submitted earlier when tests are scheduled.
The first five minutes of the class period will be devoted for turning in, and returning graded assignments.

Late assignments will be assigned only a partial grade. Please try to submit them on time since once the assignments are graded and returned to the class, late assignments cannot be accepted any more.

If you are having difficulties with an assignment, you are encouraged to seek help from the teaching assistants (TAs) during their office hours. Questions may be e-mailed to the TA's, but face-to-face interaction is more beneficial.

Although you are encouraged to consult with each other if you are having difficulties, you are kindly expected to submit work that shows your individual effort. Please do not submit a copy of another person's work as your own. Copies of other people's assignments are not conducive to learning, and are unacceptable.

For further information, please read the detailed assignments guidelines.