

NPRE 402
Nuclear Power Engineering
 Fall 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.

Threat of Nuclear War:

- <https://www.youtube.com/watch?v=HSC7Lp1nvx8>
<https://www.youtube.com/watch?v=M7hOpT0IPGI>

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.

Number	Date Assigned	Due Date	Description
1	8/21	8/28	<p>Reading assignment Preface Written Assignment Write a paragraph about the “Fermi Paradox”.</p> <p>Define the Megawatt, Gigawatt and Terawatt units 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.</p> <p>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?</p> <p>What is the percentage share of nuclear energy in: a) The primary energy supply, b) Electrical energy generation?</p> <p>Define the Quad unit of energy in terms of BTUs and Joules. Use the “Sankey diagram” to calculate the end use efficiencies of the following energy sectors: 1. Residential, 2. Commercial, 3. Industrial, 4. Transportation.</p>
2	8/23	8/30	Reading assignment

			<p><u>Preface</u> Written Assignment Draw a diagram and list the components of the envisioned Internet of Things (IoT) for a future energy system.</p> <p>Once built and operational, nuclear power plants become cash cows for their operators. Consider a 1,000 Mwe nuclear power plant costing about \$5,000 per installed kWe of capacity. Calculate: 1. The capital cost of the plant in billions of dollars. 2. If it operates for 60 years at a capacity factor of 90 percent, the amount of electrical energy in kW.hr it would produce per year. 3. Sold to electrical consumers at a profit over expenses of 6 cents / kW.hr, the generated profit stream in \$ million /year. 4. The total profit in \$ billion over its projected 60 years of operation.</p>
3	8/25	9/1	<p>Reading assignment 1. <u>First Human Made Reactor and Birth of Nuclear Age</u> Written Assignment 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.</p> <p>Compare the operating power levels of the following reactors: 1. CP1, Chicago pile 1 2. X-10 graphite reactor 3. Hanford piles 4. Typical Pressurized or Boiling Water power plant.</p>
4	8/28	9/4	<p>Reading assignment 1. <u>First Human Made Reactor and Birth of Nuclear Age</u> Written Assignment Data mine the Chart of the Nuclides for the following information on elements used in nuclear applications: 1. <i>Naturally</i> 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)</p> <p>Identify three elements that have a single naturally occurring isotope.</p>
5	8/30	9/6	<p>Reading assignment 1. <u>First Human Made Reactor and Birth of Nuclear Age</u> Written Assignment</p>

			<p>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:</p> <ol style="list-style-type: none"> 1. U^{235} 2. Pu^{239} 3. U^{233} 4. Np^{237} <p>that would release 1 kT of TNT equivalent of energy.</p> <p>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.</p> <p>Hint: Use Avogadro's law to estimate the number of nuclei in a given weight of the fissile material:</p> $N[\text{nuclei}] = \frac{g[\text{gm}]}{M[\text{amu}]} A_v, \quad A_v = 0.6 \times 10^{24} \left[\frac{\text{nuclei}}{\text{mole}} \right]$
6	9/1	9/8	<p>Reading Assignment 4. Nuclear World</p> <p>Written Assignment What do the following nuclear-related acronyms stand for? ICBM, ABM, MIRV, kT, MT, DU, HEU, NPT, MAD, TNT, SALT, UUV, UAV.</p>
7	9/6	9/13	<p>Reading Assignment 4. Nuclear World</p> <p>Written Assignment The reported time for an ICBM to travel from the continental USA to its assigned target is about $t = \frac{1}{2}$ hour. To cover the distance of 6,000 miles, calculate the speed of travel of the missile in miles / hour. What would the hypersonic Mach Number be? Hint: Use the speed of sound as 761.2 miles /hour.</p> <p>Read then write a one paragraph summary of the paper: Magdi Ragheb, "Restoring The Global Equatorial Ocean Current Using Nuclear Excavation," i-manager's Journal on Future Engineering & Technology, Vol. 5, No. 1, pp. 74-82, August-October, 2009.</p> <p>Read then write a one paragraph summary of the paper: Magdi Ragheb, "Lanchester Law, Shock and Awe Strategies," J. Def. Manag. 2015, 6:1, http://dx.doi.org/10.4172/2167-0374.1000137</p>
8	9/8	9/15	<p>Reading Assignment 4. Nuclear Processes, The Strong Force</p> <p>Written Assignment Apply conservation of charge and nucleons to balance the following nuclear reactions:</p> <ol style="list-style-type: none"> 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 DHe³ 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)

			<p>8. ${}_0^1\text{n} + {}_5^{10}\text{B} \rightarrow {}_2^4\text{He} + ?$ (neutron absorption reaction)</p> <p>Combine the two equations for the energy of a mass m and the energy of radiation with a frequency ν and a wavelength λ:</p> $E = mc^2 \text{ [ergs]}$ $E = h\nu = h \frac{c}{\lambda}$ <p>to deduce the equation that establishes the equivalence of mass and radiation:</p> $m = R\nu$ <p>where: $R = \frac{h}{c^2} = 7.365864 \times 10^{-48} \frac{\text{erg}\cdot\text{sec}^3}{\text{cm}^2}$ is a constant of nature.</p>
9	9/11	9/18	<p>Reading Assignment 4. Nuclear Processes, The Strong Force</p> <p>Written Assignment Apply conservation of mass/energy to calculate the Q values the following binary reactions:</p> <ol style="list-style-type: none"> ${}_1^2\text{D} + {}_1^3\text{T} \rightarrow {}_0^1\text{n} + ?$ (DT fusion reaction) ${}_1^2\text{D} + {}_1^2\text{D} \rightarrow {}_1^1\text{H} + ?$ (Proton branch of the DD fusion reaction) ${}_1^2\text{D} + {}_1^2\text{D} \rightarrow {}_0^1\text{n} + ?$ (Neutron branch of the DD fusion reaction) ${}_1^2\text{D} + {}_2^3\text{He} \rightarrow {}_2^4\text{He} + ?$ (Aneutronic or neutronless DHe³ reaction). <p>Calculate the Q values or energy releases in MeV from the following nuclear fission reactions:</p> <ol style="list-style-type: none"> ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow 3 {}_0^1\text{n} + {}_{53}^{137}\text{I} + {}_{39}^{96}\text{Y}$ ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow 3 {}_0^1\text{n} + {}_{54}^{136}\text{Xe} + {}_{38}^{97}\text{Sr}$ <p>For the DT fusion reaction, use conservation of momentum to determine how is the kinetic energy release distributed among the two product nuclei?</p>
10	9/13	9/20	<p>Reading Assignment 1. Radioactive Transformations Theory, The Weak Force</p> <p>Written Assignment Prove that the heuristic and the differential calculus forms of the law of radioactive decay are equivalent.</p> <p>Tritium, an isotope of hydrogen used in fusion systems and a nanotechnology and Micro Electro-Mechanical Systems (MEMS) power source devices, decays through the following reaction:</p> ${}_1^3\text{T} \rightarrow {}_{-1}^0\text{e} + \underline{\hspace{2cm}}$ <p>Using the law of radioactive decay calculate the fraction of the tritium isotope $(N_0 - N(t))/N_0$ decaying into the He³ isotope. The half-life of tritium is 12.33 years.</p> <ol style="list-style-type: none"> Within 1 year. Within 12.33 years. Within 24.66 years.
11	9/15	9/22	<p>Reading Assignment 1. Radioactive Transformations Theory, The Weak Force</p> <p>Written Assignment Calculate the activity of 1 gm of the radium isotope Ra²²⁶ in Becquerels and Curies. Discuss the relationship to the Curie (Ci) unit of activity.</p>

			<p>The production of carbon¹⁴ with a half-life of 5,730 years is an ongoing nuclear transformation from the neutrons originating from cosmic rays bombarding nitrogen¹⁴ in the Earth's atmosphere:</p> <p>Carbon exists as C¹⁴O₂ and is inhaled by all fauna and flora. Because only living plants continue to incorporate C¹⁴, and stop incorporating it after death, it is possible to determine the age of organic archaeological artifacts by measuring the activity of the carbon¹⁴ present. Two grams of carbon from a piece of wood found in an ancient temple are analyzed and found to have an activity of 20 disintegrations per minute (dpm). Estimate the approximate age of the wood, if it is assumed that the current equilibrium specific activity of C¹⁴ in carbon has been constant at 13.56 disintegrations per minute per gram.</p>
12	9/18	9/25	
13	9/20	9/27	

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.