NPRE 402
Nuclear Power Engineering
Spring 2021

<u>Online Temporary Coverage and access during Covid-19 Pandemic</u>
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://compass2g.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.

Number	Date Assigned	Due Date	Description
1	1/**25**	2/**1**	**Reading assignment** NEW **Preface** **Written Assignment** On the Kardashev Scale, identify the power needs in Watts for Type I, II and III civilizations. What is the current position of human civilization on that scale? In how many years is Humanity expected to achieve a Type I status?
2	1/**27**	2/3	**Reading assignment** NEW **Preface** **Written Assignment** Define the Quad unit of energy in terms of BTUs and Joules. 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? Hint: Define $\text{Sector Efficiency} = \frac{\text{Useful Power output}}{\text{Rejected Power} + \text{Useful Power output}}$
3	1/29	2/5	**Reading assignment** NEW **1. First Human Made Reactor and Birth of Nuclear Age** **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. 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	2/**1**	2/**8**	**Reading assignment** **1. First Human Made Reactor and Birth of Nuclear Age** **Written Assignment** Compare the power levels in thermal Watts(th) of the following reactor designs: 1. Chicago Pile CP-1 2. Oak Ridge, Tennessee X-10 3. Hanford K reactor 4. Clinton, Illinois Boiling Water Reactor (BWR) Identify the date, time and location of the Trinity test.
5	2/3	2/10	**Reading assignment** **1. First Human Made Reactor and Birth of Nuclear Age** **Written Assignment** The yield from the Hiroshima device was 12.5 kT of TNT equivalent, and the yield from the Nagasaki device was 22 kT of TNT. Assuming that one critical mass of lead-reflected U^{235} Oralloy at about 30 kgs, and one critical mass of Pu^{239} at about 10 kgs were used to generate these yields, compare the energy release efficiencies of the two devices as the fraction or percentage of the mass of fissile material actually converted into energy in the case of the gun barrel (U^{235}) versus the implosion process (Pu^{239}). Hint: Use the data in Table 2 in the notes.
6	2/5	2/12	**Reading assignment** **2. German Nuclear Program** **3. Japanese Nuclear Weapons Program** **Written Assignment** List the names of the main scientific personalities involved in: 1. German nuclear program 2. Japanese nuclear program
7	2/8	2/15	**Reading assignment** **6. Natural Nuclear Reactors, The Oklo Phenomenon** **Written Assignment** Write the “four-factor” formula and identify its different components.

<table>
<tr>
<td></td>
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<td>
Complete the table for the Variation of U^{235} enrichment in years before present (bp).
<table>
<tr><th>Percent U^{235} enrichment
a/o</th><th>Geological Time
billion (10^9) of years bp.</th></tr>
<tr><td>0.72</td><td></td></tr>
<tr><td>1.30</td><td></td></tr>
<tr><td>1.60</td><td></td></tr>
<tr><td>2.30</td><td></td></tr>
<tr><td>4.00</td><td></td></tr>
<tr><td>7.00</td><td></td></tr>
</table>
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<tr>
<td>8</td>
<td>2/10</td>
<td>2/19</td>
<td>
Reading assignment
4. Nuclear Processes, The Strong Force
Written Assignment
Complete the following nuclear reactions occurring when radioactive materials such as radium are placed in a sealed container of air. Small amounts of hydrogen, which does not exist in ordinary air, would appear.

$$_{88}Ra^{226} \rightarrow {}_{86}Rn^{222} + ?$$
$$? + {}_{7}N^{14} \rightarrow {}_{1}H^{1} + ?$$
$$\overline{}$$
$$_{88}Ra^{226} + {}_{7}N^{14} \rightarrow {}_{1}H^{1} + ? + ?$$

Apply conservation of charge and of nucleons to balance the following fissile breeding reaction:

$$_{0}n^{1} + {}_{92}U^{238} \rightarrow {}_{92}U^{?}$$
$$_{92}U^{?} \rightarrow {}_{-1}e^{0} + {}_{?}?^{?}$$
$$_{?}?^{?} \rightarrow {}_{-1}e^{0} + {}_{?}?^{?}$$
$$-----------------$$
$$_{0}n^{1} + {}_{92}U^{238} \rightarrow 2\,{}_{-1}e^{0} + {}_{?}?^{?}$$
</td>
</tr>
<tr>
<td>9</td>
<td>2/12</td>
<td>2/19</td>
<td>
Reading assignment
4. Nuclear Processes, The Strong Force
Written Assignment
Apply conservation of charge and nucleons to balance the following nuclear reactions:
1. ${}_{1}D^{2} + {}_{1}T^{3} \rightarrow {}_{0}n^{1} + ?$ (DT fusion reaction)
2. ${}_{1}D^{2} + {}_{1}D^{2} \rightarrow {}_{1}H^{1} + ?$ (Proton branch of the DD fusion reaction)
3. ${}_{1}D^{2} + {}_{1}D^{2} \rightarrow {}_{0}n^{1} + ?$ (Neutron branch of the DD fusion reaction)
4. ${}_{1}D^{2} + {}_{2}He^{3} \rightarrow {}_{2}He^{4} + ?$ (Aneutronic or neutronless DHe^{3} reaction).
5. ${}_{0}n^{1} + {}_{3}Li^{6} \rightarrow ? + ?$ (tritium breeding reaction)
6. ${}_{0}n^{1} + {}_{3}Li^{7} \rightarrow {}_{0}n^{1} + ? + ?$ (tritium breeding reaction)
7. ${}_{1}T^{3} + {}_{1}T^{3} \rightarrow 2\,{}_{0}n^{1} + ?$ (neutron multiplier reaction)
8. ${}_{0}n^{1} + {}_{5}B^{10} \rightarrow {}_{2}He^{4} + ?$ (neutron absorption reaction)
</td>
</tr>
</table>

10	2/15	2/22	**Reading assignment** **4. Nuclear Processes, The Strong Force** **Written Assignment** Apply conservation of momentum and energy to calculate the Q values and the kinetic energies of the product nuclei from the following binary reactions: 1. ${}_1D^2 + {}_1T^3 \rightarrow {}_0n^1 + ?$ (DT fusion reaction) 2. ${}_1D^2 + {}_1D^2 \rightarrow {}_1H1 + ?$ (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). Calculate the Q values or energy releases in MeV from the following nuclear fission reactions: 1. ${}_0n^1 + {}_{92}U^{235} \rightarrow 3\ {}_0n^1 + {}_{53}I^{137} + {}_{39}Y^{96}$ 2. ${}_0n^1 + {}_{92}U^{235} \rightarrow 3\ {}_0n^1 + {}_{54}Xe^{136} + {}_{38}Sr^{97}$
11	2/17	2/24	Campus day off, no classes
12	2/19	2/26	**Reading assignment** **4. Nuclear World** **Written Assignment** Combine the two equations for the energy of a mass m and the energy of radiation with a frequency υ and a wave length 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: $R = \frac{h}{c^2} = 7.365864 \times 10^{-48} \frac{erg.sec^3}{cm^2}$ is a constant of nature. The reported time for an ICBM to travel from the continental USA to its assigned target is about t = ½ hour. To cover a 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.
13	**2/22**	3/1	**Reading assignment** **4. Nuclear World** **Written Assignment** What do the following acronyms stand for: CP1 TNT kT mT NPT IAEA NATO MAD ICBM

			MIRV ABM LTBT CTBT SALT INF THAAD START ICAN In a possibly future matter/antimatter reactor, use the mass to energy equivalence relationship to calculate the energy release in ergs, Joules and MeV from the complete annihilation of: a. An electron/positron pair. b. An antiproton/proton pair. Consider the following masses: $m_{electron} = m_{positron} = 9.10956 \times 10^{-28}$ gram $m_{proton} = m_{antiproton} = 1.67261 \times 10^{-24}$ gram.
14	2/24	3/1	**Reading assignment** **1. Radioactive Transformations Theory, The Weak Force** **Written Assignment** Prove that the heuristic and the differential-calculus forms of the law of radioactive decay are equivalent. Calculate the activity of 1 gm of the radium isotope Ra^{226} in Becquerels and Curies. Discuss the relationship to the Curie, Ci unit of activity. 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: ${}_1T^3 \rightarrow {}_{-1}e^0 +$ ______ Using the law of radioactive decay calculate the fraction of the tritium isotope $(N_0-N(t))/N_0$ decaying into the He^3 isotope. The half-life of tritium is 12.33 years. 1. Within 1 year. 2. Within 12.33 years. 3. Within 24.66 years. $Radon^{222}$ as a daughter in the decay chain of uranium is gaseous at room temperature. It is an inert or noble gas that does not interact chemically in the body. However it decays into Pb^{210} which attaches itself to vegetation such as tobacco leaves as a solid and subsequently decays into Po^{210} which emits an energetic alpha particle with 5.3 MeV of energy. The inhalation of these two isotopes in the particulate matter of cigarettes smoke delivers to the average smoker a radiation dose equivalent or dose equivalent of 8 rems (radiation equivalent man) per year to the basal cells of the bronchial tissue. The "cancer dose" is the total radiation dose that if spread through a population would cause one additional cancer death and is considered to be approximately

			2,000 rems. Calculate the ensuing radiological risk in units of cancer deaths per year in a population of one million smokers.
15	2/26	3/1	**Reading assignment** **3. Radioisotopes Power Production** **Written Assignment** Design a radioisotope power generator for space applications using the isotope $_{84}$Polonium^{210}. If its specific thermal power is 141[Watts(th)/gm], its half-life is 0.38 year, and the thermal to electrical conversion efficiency is 40 percent, determine: 1. The weight of the isotope needed to produce 30 Watts(e) of electrical power. 2. The electric power after 0.76 year of operation. 3. The electric power after 1.52 years of operation.
	3/1	3/1	NPRE 402 Spring 2021 First Midterm To be taken and submitted on Monday, March 1st, 2021. Please submit test answers as an email attachment to: *****
16	3/3	3/10	**Reading assignment** **2. Food Preservation by Radiation** **3. Terrestrial Radioactivity and Geothermal Energy** **Written Assignment** Match the following radiological quantities to their respective equivalents: 1 Curie 100 [ergs/gm] 1 Becquerel 1[Joule/kg] 1 rad 1 [trans/sec] 1 Gray 3.7x10^{10}[trans/sec] List the 'fumigation" chemicals currently used in the protection of grain supplies from rodents and insects. The production of carbon^{14} with a half-life of 5,730 years is an ongoing nuclear transformation from the neutrons originating from cosmic rays bombarding nitrogen^{14} in the Earth's atmosphere: Carbon exists as $C^{14}O_2$ and is inhaled by all fauna and flora. Because only living plants continue to incorporate C^{14}, and stop incorporating it after death, it is possible to determine the age of organic archaeological artifacts by measuring the activity of the carbon^{14} 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 C^{14} in carbon has been constant at 13.56 disintegrations per minute per gram.
17	3/5	3/12	**Reading assignment** **1. Nuclear Reactor Concepts and Thermodynamic Cycles** **Written Assignment** List the general principles and their corollaries underlying the processes of energy extraction and conversion from the environment. What do the following acronyms stand for: PWR, BWR, HTGR, AGR, LMFBR. List the Engineered Safety Features ESFs, of: 1. The PWR concept,

			2. The BWR concept.
18	3/8	3/15	**Reading assignment** **1. Nuclear Reactor Concepts and Thermodynamic Cycles** **Written Assignment** A Stirling cycle engine using a radioactive isotope for space power applications operates at a hot end temperature of 650 ^{o}C and rejects heat through a radiator to the vacuum of space with a cold end temperature at 120 ^{o}C. Calculate its ideal Stirling cycle efficiency. Assuming that heat rejection occurs at an ambient temperature of 20 degrees Celsius, for the average heat addition temperatures T_a given below, compare the Carnot cycle thermal efficiencies of the following reactor concepts: 1. PWR, 168 ^{o}C. 2. BWR, 164 ^{o}C. 3. CANDU, 141 ^{o}C. 4. HTGR, 205 ^{o}C. 5. LMFBR, 215 ^{o}C.
19	3/10	3/17	**Reading assignment** **2. Pressurized Water Reactors** **3. Boiling Water Reactors** **Written Assignment** A Boiling Water Reactor (BWR) produces saturated steam at 1,000 psia. The steam passes through a turbine and is exhausted at 1 psia. The steam is condensed to a subcooling of 3^{o}F and then pumped back to the reactor pressure. Compute the following parameters: a. Net work done per pound of fluid. b. Heat rejected per pound of fluid. c. Heat added by the reactor per pound of fluid. d. The turbine heat rate defined as: [(Heat rejected +Net turbine work)/Net turbine work] in units of [BTU/(kW.hr)] e. Overall Thermal efficiency. You may use the following data: From the ASME Steam Tables, saturated steam at 1,000 psia has an enthalpy of h = 1,192.9 [BTU/lbm]. At 1 psia pressure the fluid enthalpy from an isentropic expansion is 776 [BTU/lbm]. The isentropic pumping work is 2.96 [BTU/lbm]. The enthalpy of the liquid at 1 psia subcooled to 3 ^{o}F is 66.73 [BTU/lbm]. 1 [kW.hr] = 3,412 [BTU]
20	3/12	3/19	**Reading assignment** **3. Boiling Water Reactors** **Written Assignment** Construct a table comparing the Technical Specifications of typical: 1. PWR 2. BWR Reactor concepts. 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 5 cents / kW.hr, the generated income stream in $ million /year. 4. The total income stream in $ billion over 60 years of operation.
21	3/15	3/22	**Reading assignment** **1. Energy Hydrogenation and Decarbonization** **Written Assignment** High Temperature Electrolysis (HTE) has a high efficiency $\eta_{electrolysis} > 0.90$. Calculate the efficiency of a hydrogen production system for a future transportation alternative for the cases of: 1. A nuclear system using the Steam Cycle with an overall thermal efficiency of 33.3 percent, 2. A nuclear system using the Brayton Gas Turbine Cycle with an overall thermal efficiency of 60 percent. Compare the voltages generated by a single fuel cell element using hydrogen as an energy carrier when it is operated at: a. 20 ºC, b. 100 ºC. Use: n =2, $\Delta E = \frac{T\Delta S - \Delta H}{n.F}$, $\Delta S = -163.2\ J/K$, $\Delta H = -285{,}800\ J$, F (Faraday's constant) = 96,487 [Coulombs] or [Joules/Volt]. How many primary cells are needed for the generation of 12 volts?
22	3/17	3/26	**Reading assignment** **4. High Temperature Gas Cooled Reactor** **5. Heavy Water Reactor** **13. Underwater Power Plants** **14. Floating Nuclear Barges** **Written Assignment** For heat rejection at 20 degrees Celsius, compare the Carnot cycle efficiencies for an HTGR operating in the following modes: a) Process heat, b) Power generation, c) Hydrogen production. Compare the prices of electricity produced by: 1. CANDU reactor 2. Coal 3. Natural gas at capacity factors of: 1. 20 percent, 2. 80 percent.
23	3/19	3/26	**Reading assignment** **7. Fast Breeder Reactors** **8. Autonomous Battery Reactors** **Written Assignment** Identify the coolants materials used in the different reactor designs: 1. EBR I 2. EBR II

			3. Super Phénix 4. Hyperion 5. NU-SCALE SMR Breeding in the thorium fuel cycle would follow the chain reactions: ${}_0n^1 + {}_{90}Th^{232} \rightarrow {}_{90}Th^?$ ${}_{90}Th^? \rightarrow {}_{-1}e^0 + {}_?\,?^?$ ${}_?\,?^? \rightarrow {}_{-1}e^0 + {}_?\,?^?$ $- - - - - - - - - - - - - - -$ ${}_0n^1 + {}_{90}Th^{232} \rightarrow 2\,{}_{-1}e^0 + {}_?\,?^?$
24	3/22	3/29	**Reading assignment** **6. Fourth Generation Reactor Concepts** **11. Traveling Wave Reactor** **12. Modular Integral Compact Underground Reactor** **Written Assignment** List the reactors concepts considered in the "Fourth Generation" initiative and their associated acronyms. Identify the level of enrichment of: 1. Natural uranium, 2. Enrichment level of Depleted Uranium, DU, 3. Level of enrichment for LWRs. List the main characteristics of the "Modular Integral Compact Reactor"
	3/24		Campus day off. No classes.
25	3/26	4/2	**Reading assignment** **10. Isotopic Separation and Enrichment** **Written Assignment** Write a list of the: 1. Fissile isotopes 2. Fissionable isotopes List the names of the methods used for the production of heavy water
26	3/29	4/5	**Reading assignment** **10. Isotopic Separation and Enrichment** **Written Assignment** An executive at an electrical utility company needs to order natural uranium fuel from a mine. The utility operates a single Heavy Water Reactor (HWR) 500 MWe power plant of the CANDU type using natural uranium, and operating at an overall thermal efficiency of 1/3. What is the yearly amount of: a. U^{235} burned up by the reactor? b. U^{235} consumed by the reactor? c. Natural uranium fuel that the executive has to contract with the mine per year as feed to his nuclear unit? An executive at an electrical utility company needs to order uranium fuel from a mine for a single 500 MW(e) PWR power plant operating at an overall thermal efficiency of 33 percent. The fuel needs to be enriched to the 5 w/o in U^{235} level. The enrichment plant generates tailings at the 0.20 w/o in U^{235} level. What is the yearly amount of natural uranium that the executive has to contract

<table>
<tr><td></td><td></td><td></td><td>with the mine as feed to his nuclear unit?</td></tr>
<tr><td>27</td><td>3/31</td><td>4/5</td><td>Reading assignment
10. Isotopic Separation and Enrichment
Written Assignment
List the methods used in the enrichment of the heavy-element isotopes.

Compare the ratio and the difference in the separation radii in the electromagnetic separation method (Calutron) for the separation of the ions of the isotopes and molecules of:
a) U^{235} and U^{238},
b) Li^6 and Li^7.</td></tr>
<tr><td>28</td><td>4/2</td><td>4/5</td><td>Reading assignment
5. Gamma Rays Interaction with Matter
Written Assignment
List the different processes of gamma rays interaction with matter.

Compare the thicknesses of the following different materials that would attenuate a narrow beam of 1 MeV gamma-rays in “good geometry” with a build-up factor of unity to one millionth of its initial strength, given their linear attenuation coefficients in cm^{-1}:
<table>
<tr><th>Material</th><th>Density [gm/cm^3]</th><th>Linear attenuation coefficient, μ at 1 MeV,[cm^{-1}]</th></tr>
<tr><td>Pb</td><td>11.3</td><td>0.771</td></tr>
<tr><td>H_2O</td><td>1</td><td>0.071</td></tr>
<tr><td>Concrete</td><td>2.35</td><td>0.149</td></tr>
</table>
Hint: Use the gamma-rays exponential attenuation law:
$I(x) = I_0 B(\mu x, E_\gamma).e^{-\mu(E_\gamma).x}$
.</td></tr>
<tr><td></td><td>4/5</td><td>4/5</td><td>NPRE 402 Spring 2021 Second Midterm.
To be taken and submitted on Monday, April 5, 2021.
Please submit test answers as an email attachment in the word docx format to: *****</td></tr>
<tr><td>29</td><td>4/7</td><td>4/14</td><td>Reading assignment
2. Ionizing Radiation Units and Standards
Written Assignment.
Show in the table the corresponding units and their abbreviations of the following radiological quantities
<table>
<tr><th>Radiological quantity</th><th>Conventional System Unit</th><th>SI System Unit</th></tr>
<tr><td>Effective dose, dose equivalent</td><td></td><td></td></tr>
<tr><td>Absorbed dose</td><td></td><td></td></tr>
<tr><td>Exposure</td><td></td><td></td></tr>
<tr><td>Activity</td><td></td><td></td></tr>
</table>
Approximate overall annual dose equivalent to a person in the USA is: _______________.
The maximum allowable yearly dose equivalent for occupational exposure is: __________.
alara stands for: ________________________.
RBE stands for: ________________________</td></tr>
<tr><td>30</td><td>4/9</td><td>4/16</td><td>Reading assignment
2. Ionizing Radiation Units and Standards
Written Assignment.</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td>
Standards for Limiting radiation effective doses:

<table>
<tr><th>Category</th><th>Maximum yearly per capita effective dose
[cSv/(person.year)]
[rem/(person.year)]</th></tr>
<tr><td>Occupational workers</td><td></td></tr>
<tr><td>Members of the public</td><td></td></tr>
<tr><td>Whole population average (all sources other than medical)</td><td></td></tr>
</table>

The allowable effective dose is a cumulative figure that depends on age, thus over a lifetime the cumulative radiation effective dose to an occupational worker is:

$$\text{Effective Dose}_{\text{cumulative}} = \_\_\_\_\_\_\_\_ \left[\frac{\text{cSv}}{\text{person}}\right] \text{or} \left[\frac{\text{rem}}{\text{person}}\right]$$

where N is the age of the exposed individual in years.
</td></tr>
<tr><td>31</td><td>4/12</td><td>4/19</td><td>
Reading assignment
5. Radiation Hormesis
9. Gamma and X rays Detection
Written Assignment.
On the diagram for the dose effect curves for nuclear radiation dose, identify:
a) the curve describing the threshold hypothesis,
b) the curve describing the Linear No Threshold (LNT) relationship,
c) the curve describing the radiation hormesis concept.

Show a sketch of the electronic circuit of a Geiger-Mûller radiation detector.
</td></tr>
<tr><td>32</td><td>4/14</td><td>4/21</td><td>
Reading assignment
3. Nonionizing Radiation
Written Assignment.
For nonionizing radiation define the Specific Absorption Rate (SAR).

The Federal Communications Commission (FCC) and the Federal Drug Administration (FDA) regulate cell phones in the USA. The FCC requires that all cell phones sold in the USA have an SAR of ________ [Watts/kg] or less.
</td></tr>
<tr><td>33</td><td>4/16</td><td>4/23</td><td>
Reading assignment
1. Transport Theory
Written Assignment.
Write the general form of the Transport Equation
List the Integro-Differential form of the one-dimensional Neutron Transport Equation.
List the approximations used in solving it.
</td></tr>
<tr><td>34</td><td>4/19</td><td>4/26</td><td></td></tr>
<tr><td>35</td><td>4/21</td><td>4/28</td><td></td></tr>
</table>

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.