First Exam
NEEP-602
Nuclear Power in Space
March 3, 2000

10 pts 1.) a.) What is the maximum voltage that you can develop in the following thermionic system at 2000 °K?

Neglect space charge.

Emitter Work Function, eV	4.53
Collector Work Function, eV	4.16

b.) What current density would this produce if the constant A in the Richardson-Dushman equation is ;

$A = 10$ amps/cm^2 °K^2
$1/k = 11{,}600$ ° K /eV

10 Pts 2.) a.) Contrast the thermal efficiencies of Thermoelectric, Thermionic, Rankine, Brayton, and Stirling cycles in Space.

b.) Give 2 major disadvantages of a Rankine cycle in space?

14 pts 3.) D^{3}He Fusion rockets with direct exhaust of reaction products can develop much higher specific impulses than fission rockets heating hydrogen. Why is this true and what is the ratio of I_{sp} values if only the proton in the D^{3}He reaction is released out the nozzle?

10 pts 4.) a.) The US and the former Soviet Union chose different ways to power their military satellites. What choices were made and approximately how many nuclear systems were launched by each? Approximately how many nuclear systems are still orbiting the Earth?

b.) How does the U.S. provide power to commercial communications satellites now?

16 Pts 5) Give three reasons why the ^{3}He(d,p)^{4}He reaction appears likely to lead to larger specific powers (kW/kg) than the T(d,n)^{4}He reaction

20 pts 6.) Assume that you were given 2 thermoelectric couples, A & B , with the following properties;

	A	B
Seebeck Coeff., mV /°K	550	350
Therm. Conductance, W/°K	5	10
Resistance, ohm	20	10
T_{hot}/T_{cold}, °K	1000/500	1200/400

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* use $\eta_{mat} \approx \dfrac{m-1}{\left(\dfrac{T_L}{T_H}\right)+m}$ where Z = Fig. of Merit

and $m=\sqrt{1+Z\overline{T}}$

$$\overline{T}=\left(\frac{T_H+T_L}{2}\right)$$

Which TE couple would you chose to obtain the highest overall efficiency and why ?

20 7.) You are told to buy the fuel for a RTG the will generate at least 100 W_e for 5 years with a 5% efficient thermoelectric unit. Assume that you chose Co -60 ($t_{1/2}$ = 5.24 y) with a 1.3 MeV gamma ray decay. How much (kg) Co do I need if the Co-60 content is 10% ?

Note 1 Watt = 6.24 x 10^{18} eV/s