85 Late -6 = $\boxed{79}$

Exam 1 Fed. Fehi 11/02/2021

Exercise 1

$$\frac{\partial}{\partial x}\left(k\left(\frac{\partial T}{\partial x}\right)\right) + Q = 0 \quad (1)$$

$$k\frac{\partial T}{\partial x} = -Qx + C_1 \qquad T'(0) = 0$$ ✓ 12/12

$$\Rightarrow C_1 = 0$$

$$k\frac{\partial T}{\partial x} = -Qx$$

$$T(x) = -\frac{Qx^2}{2k} + C_2$$ ✓

$$T(x_1) = T_1 \qquad T(X) = -\frac{QX^2}{2k} + C_2 = T_1$$

$$\Rightarrow C_2 = T_1 + \frac{QX^2}{2k}$$

$$T(x) = -\frac{Qx^2}{2k} + \frac{QX^2}{2k} + T_1$$ ✓

$$T(x) - T_1 = \frac{Q(X^2 - x^2)}{2k}$$ ✓

LHR

To get to equation (1) Few assumption were made

#1 : Steady state $\nabla \cdot (K \nabla T) + Q = 0$

#2 : axisymmetric

$$\frac{\partial}{\partial x}\left(K \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial z}\left(K \frac{\partial T}{\partial z}\right) + Q(x,z) = 0$$

same thing here

#3 constant in Z

$$\frac{\partial}{\partial x}\left(K \frac{\partial T}{\partial x}\right) + Q(x) = 0$$

#4 constant thermal conductivity :

equation 1

Exercice 2.

13/18

~~$T_{outer\ coating} - T_{clad} =$~~

$LHR = \cancel{2}\,\pi R^2 Q = \pi \times (0,6)^2 \times 400 = 452,38\ W/cm$

$t_{coating} = \frac{r_4 - r_3}{\cancel{2}} = 0,005\ cm$ ~ why divide by 2?

$t_{clad} = \frac{r_3 - r_2}{\cancel{2}} = 0,025\ cm$

$t_{gap} = \frac{r_2 - r_1}{\cancel{2}} = 0,1\ cm$

$T_{coating} - T_{cod} = \frac{LHR}{2\pi R_{fuel} h_{coolant}} = \frac{452,38}{2\pi \times 0,6 \times 5,5}$ -5

$T_{coating} - T_{cod} = 21,81\ K$

$T_{coating} = 21{,}81\,K + 800$

$T_{coating} = 821{,}81\,K$

$$T_{clad} - T_{coating} = \frac{LHR \times t_{coating}}{2\pi R_{fuel} K_{coating}}$$

$$= \frac{452{,}38 \times 0{,}005}{2\pi \times 0{,}6 \times 5/100\ W/cmK} \sim \times 2$$

$T_{clad} - T_{coating} = 12\ K \quad \times 2$

$T_{clad} = 821{,}81 + 12 = 833{,}81\,K$

$$T_{gap} - T_{clad} = \frac{LHR\ r_{clad}}{2\pi R_f \times K_{clad}} = \frac{452{,}38 \times 0{,}025}{2\pi \times 0{,}6 \times 15/100} \sim \times 2$$

$T_{gap} - T_{clad} = 20\ K \quad \times 2$

$T_{gap} = 20 + 833{,}81\,K = 853{,}81\,K$

$$T_{fuel} - T_{gap} = \frac{LHR\ t_{gap}}{2\pi R_f K_{gap}} = \frac{452{,}38 \times 0{,}1}{2\pi \times 0{,}6 \times 25/100} \sim \times 2$$

$T_{fuel} = 48\,K + T_{gap} \quad \times 2$

$T_{fuel} = 901{,}33\,K$

$$T_0 - T_{fuel} = \frac{LHR}{4\pi K_{fuel}}$$

$$= \frac{452,38}{4\pi \times 0,5}$$

$$T_0 - T_{fuel} = 72 \text{ K}$$

$$\boxed{T_0 = 72 + 901,33 = 973,33 \text{ K}}$$

$$\cancel{T_0} \quad T_R - T_{fuel} = \frac{Q}{4k}(R_f^2 - r)$$

for $r = 0,4$

$$T_{(0,4)} = \frac{Q}{4k}(0,6^2 - 0,4^2) + 901,33$$

$$= 40 + 901,33$$

$$T_{(r=0,4)} = 941,33 \text{ K}$$

→ underestimating T_0 by 110 K

→ $r_2 - r_1 = t_2$,

– no need to divide by 2

Exercice 7

7/14

$Q = E_F \times N_F \times \phi \times \sigma_F$

m... $U_3Si_2 = 3 \times (235 \times 0{,}195 + 238 \times 0{,}805)$
$+ 2 \times 28$

$U_3Si_2 = 237{,}415 \times 3 + 2 \times 28 = 768{,}245 \text{ g/l}$ ✓

$N_F = \frac{15{,}67}{768{,}245} \times 6{,}022 \times 10^{23} \times 0{,}195 \times 3 \frac{U}{1 U_3Si_2}$

$= 7{,}18 \times 10^{21}\ U^{235}/cm^3$ ✓

$Q = (200 \times 10^6 \times 1{,}6 \times 10^{-19}) \times 7{,}18 \times 10^{21} \times 2 \times 10^{12} \times 570 \times 10^{-24}$

$Q = 261{,}92 \text{ W}/cm^3$ ✓

$\frac{Q_{vol}}{Q}$ no   3b -7

7/12

$z_0 = 1.5 = \frac{3}{2}$

Exercice 4

$LHR\left(\frac{z}{z_0}\right) = LHR^0 \cos\left(\frac{\pi}{2\gamma}\left(\frac{z}{z_0} - 1\right)\right)$

$LHR\left(\frac{1.8}{3}\right) = 150 \cos\left(\frac{\pi}{2.12}\left(\frac{1.8}{3} - 1\right)\right)$

$LHR\left(\frac{1.8}{3}\right) = 126{,}18$ W/cm $\times 2$

$T_{cool_{Solic}} = T_{rad_{lim}}^{in} = \frac{2.2}{\pi} \times \frac{180 \times 150}{0.78 \times 1300} \times \left(\sin\left(\frac{\pi}{2\gamma}\right) + \sin\left(\frac{\pi}{2\gamma}\, 0\right)\right)$

$= 10{,}85 \times (0{,}98$

$= 10{,}65$ K for Solin

Started but not finished

16/16

Exercice 5

Forward euler

$$f(t_{n+1}) = f(t_n) + d + \frac{df}{dt_n}$$

$$y(t_1) = y(0) + 0,33\ (4 - 3 \times 1^2)$$

$$= 6 + 0,33$$

$$y(1,33) = 6,33$$

$$y(t_2) = y(t_1) + 0,33 \times (4 \times 1,33 - 3 \times 1,33^2)$$

$$= 6,33 + 0,0133$$

$$y(1,66) = 6,334$$

$$y(t_3) = y(t_2) + 0,33 \times (4 \times 1,66 - 3 \times 1,66^2)$$

$$= 6,334 + 0,33 \times (-1,628)$$

$$y(2) = 5,797$$

Backward euler

$y(t_1) = y(t_0) + 0{,}33\,(4 \times 1{,}33 - 3 \times 1{,}33^2)$

$= 6 + 0{,}33 \times 0{,}0133$

$y(1{,}33) = 6{,}004$ ✓

$y(t_2) = y_{t_1} + 0{,}33 \times (4 \times 1{,}66 - 3 \times 1{,}66^2)$

$= 6{,}004 - 0{,}53$

$y(1{,}66) = 5{,}467$ ✓

$y(t_3) = y_{t_2} + 0{,}33 \times (4 \times 2 - 3 \times 2^2$

$y(1) = 4{,}142$ ✓

Exercice 6

* a Fertile material is a material that is not fissionable
5/5 but can be converted into a fissile nuclide
by neutron absorption

* a fissile material is capable of sustaining a
nuclear fission chain reaction with neutrons

* a fissionable material is capable of undergoing
fission even (with low probability) after
capturing a high energy neutron

Exercice 7

3/4 - because during thermal cycling Pure U metal
dramatically swells

- not stable? as pure UO_2 considering
that it has three phases -1

Exercice 8. What is smear density?

2/4 Smear density is necessary to determine the
Swelling of the fuel to determine the thickness

of the gap more void more smally

Exercice 9

9. we need to enrich U because only U-235 could sustain a nuclear chain reaction which exist naturally in UO_2 by 0,7% mass ~~percent~~ we centrifuge UF_6 for (238)

the enrichment gas

centrifuge process gas is placed in a gap centrifuge cylinder rotated at a high speed

- the heavier U-238 will be pushed to the sides of the cylinder

- the enriched UF_6 will be pull out from the center

8/8

Exercice 10

Mo and Cs one is for enrichment and the other for higher (double lamp distillation)

4/4

Exercise 11

8/8

- Finite difference
- Finite volume
- Finite element

~~Fin~~ Finite element is primary method for high fidelity fuel performance codes because it has continuous representation and can model any BCs and geometries