Prob 6.17

Given: Bare slab reactor $a_0 = 200$ cm
Homo mixture U235 and graphite
$\phi_{T\,max} = 5\times10^{12}$ n/cm²-s
use modified 1-group theory

Calc B^2

$a = a_0 + 2d$
$d = 2.13\bar{D}$

for dilute homo mixture $\bar{D} = \bar{D}_m = 0.84$ (table 5.2) graphite

$\therefore a = 200 + 4.26(.84) = 203.6$ cm

$B^2 = \left(\frac{\pi}{a}\right)^2 = \left(\frac{\pi}{203.6}\right)^2 = \boxed{2.381\times10^{-4}\ \text{cm}^{-2}}$ slab

(a) Calc critical concentration of uranium

let $\boxed{z = \frac{\bar{\Sigma}_{aF}}{\bar{\Sigma}_{am}}}$ $\therefore f = \frac{\bar{\Sigma}_{aF}}{\bar{\Sigma}_{aF} + \bar{\Sigma}_{am}} = \boxed{\frac{z}{z+1}}$

then $k_\infty = \eta_T f = \boxed{\frac{\eta_T z}{z+1}}$

Now $L_T^2 = \frac{\bar{D}}{\bar{\Sigma}_a} \simeq \frac{\bar{D}_m}{\bar{\Sigma}_a} = \frac{\bar{D}_m}{\bar{\Sigma}_{aF} + \bar{\Sigma}_{am}}\left(\frac{1/\bar{\Sigma}_{am}}{1/\bar{\Sigma}_{am}}\right)$

$\boxed{L_T^2 \simeq \frac{L_{Tm}^2}{z+1}}$ $\boxed{L_T^2 \simeq (1-f)\,L_{Tm}^2}$

also $\frac{1}{z+1} = 1 - \frac{z}{z+1} = 1 - f$

and $\boxed{\tau_T \simeq \tau_{Tm}}$

and finally $\boxed{k_{eff} = 1 = \frac{k_\infty}{1 + B^2 M_T^2}}$

where $\boxed{M_T^2 = L_T^2 + \tau_T}$ for critical

all these eqns are directly from the lecture notes

All the above quantities can be expressed in terms of Z, and the critical condition solved for Z gives

$$\boxed{Z = \frac{1 + B^2 (L_{TM}^2 + \tau_{TM})}{\eta_T k_{eff} - 1 - B^2 \tau_{TM}}}$$

$k_{eff} \to 1.000$

see Lecture Notes for details

Now, for the present case, let's collect the necessary data

$L_{TM}^2 = 3500\ cm^2$ for graphite (Table 5.2)

$\tau_{TM} = 368\ cm^2$ for graphite (Table 5.3)

$\eta_T = 2.065$ for U235 (Table 6.2)

with these values, we have

$$Z = \frac{1 + (2.381 \times 10^{-4})[3500 + 368]}{2.065 - 1 - (2.381 \times 10^{-4})(368)} = \frac{1.9210}{0.9774}$$

or $\boxed{Z = 1.965}$

and $f = \frac{Z}{Z+1} = \boxed{0.6627}$

now since $Z = \frac{N_F \bar{\sigma}_{aF}}{N_M \bar{\sigma}_{aM}}$

we have $\boxed{N_F = Z \frac{\bar{\sigma}_{aM}}{\bar{\sigma}_{aF}} N_M}$

where $\boxed{\bar{\sigma}_a = \frac{\sqrt{\pi}}{2} g_a(t)\, \sigma_a(E_0) \left(\frac{T_0}{T}\right)^{1/2}}$

Now collecting the data at $E_0 = 0.0253\,eV$ $T_0 = 20°C$

for graphite $N_m = 8.023 \times 10^{-2}$ at/b-cm } $\rho_{graphite} = 1.6 \frac{g}{cc}$

nominal density $\sigma_{am} = 3.4 \times 10^{-3}$ b { Table II.2

for $U235$ $\sigma_{aF} = 687$ b } Table II.2

$g_{aF} = 0.978$ } table 3.2

Note: The graphite data in Table 5.2 already includes the $\sqrt{\pi}/2$ factor

$\sqrt{\pi}/2$ factor cancels here

$$\therefore N_F = \frac{Z\,\sigma_{am}(E_0)}{g_{aF}(T)\,\sigma_{aF}(E_0)} N_m = \frac{(1.965)(3.4 \times 10^{-3})}{(0.978)(687)} (8.023 \times 10^{-2})$$

or $\boxed{N_F = 7.978 \times 10^{-7} \text{ at/b-cm}}$

$\frac{N_F}{N_m} = 9.94e-6$

infinitely dilute is a great approx

(a) calc thermal diffusion area

$$L_T^2 = (1-f) L_{Tm}^2$$
$$= (1 - 0.6627)(3500\ cm^2)$$
$$= \boxed{1180.6\ cm^2}$$

(b) calc k_∞

$$k_\infty = \eta_T f p \epsilon$$
$$= (2.065)(0.6627)$$
$$= \boxed{1.368}$$

but $p\epsilon \approx 1.0$ for dilute homo sys't.

(c) calc the thermal power, flux, and current

for a slab reactor

$$\phi(x) = A \cos \frac{\pi x}{a} \quad \text{where } A = \frac{1.57\,P}{a_0 K \Sigma_f}$$

assumes $a \approx a_0$

since $\phi_{max} = 5\times10^{12}$, we have

$$\boxed{\phi_T(x) = 5\times10^{12}\cos\frac{\pi x}{a}}$$

and $J_T(x) = -D\frac{d}{dx}\phi_T(x) = D\frac{\pi}{a}A\sin\frac{\pi x}{a}$

but $D \simeq \bar{D}_m = 0.84$ cm for graphite { Table 5.2

and $\frac{A D \pi}{a_0} = \frac{(5\times10^{12})(0.84)\pi}{200} = 6.597\times10^{10}$ n/cm²-s

assumes $a \simeq a_0$ which is true here

$$\therefore \boxed{J_T(x) = 6.597\times10^{10}\sin\frac{\pi x}{a}}$$

Finally $P = \frac{A a_0 \kappa \bar{\Sigma}_f}{1.57}$ { this assumes that the fast fission is small compared to thermal fission

from Lecture Notes

where $\bar{\Sigma}_f = \frac{\sqrt{\pi}}{2} g_f(T) N_F \sigma_f$

$= \frac{\sqrt{\pi}}{2}(0.976)(7.978\times10^{-7})(587)$

$= \boxed{4.051\times10^{-4}\ \text{cm}^{-1}}$

where $g_f = 0.976$ { Table 3.2

$\sigma_f(E_0) = 587$ b { Table II.2

$$\therefore P = \left(5\times10^{12}\frac{n}{cm^2\text{-}s}\right)\left(\frac{200\ cm}{1.57}\right)\left(\frac{200\ MeV}{fiss}\right)\left(1.602\times10^{-13}\frac{J}{MeV}\right)\left(4.051\times10^{-4}\ cm^{-1}\right)$$

$= 8.267\ \frac{J/s}{cm^2}$

or $\boxed{P \simeq 8.27\ W/cm^2}$

Prob 6.17
with Dilutch-gui

Solve Problem 6.17 in Lamarsh using dilutch-gui

Data Needed

Reactor type : Bare
Fuel Matl : U235/U238
Fuel Density : unknown ← this will be determined via iteration

Fissile Enrich : 100 %
Mod. matl : C-12
Mod. Density : 1.6 g/cc
Temp of core mix : 20 °C

Geometry : XYZ
Dimensions : 200 100000 100000

1-D sys so set these to be very large → infinite

Now, from the hand calc, we have

hand calc $N_F = 7.978 \times 10^{-7}$ at/b-cm

$$\therefore \rho_F = 7.978 \times 10^{-7} (10^{24}) \frac{\text{at } U235}{cm^3} \times \frac{235.04 \text{ g } U235}{0.6022 \times 10^{24} \text{ at } U235}$$

$$\boxed{\rho_F = 3.114 \times 10^{-4} \text{ g/cm}^3}$$

↳ let's start with this value and iterate as necessary

in dilutch-gui $\rho_F = 3.114e-4$ $K_{eff} = 1.003$
pretty close

and $\rho_F = 3.09e-4 \rightarrow K_{eff} = 1.00$

also see other comparisons on dilutch output file

These differences are related to round off error in hand calcs (don't know 4 sig figs)

```
    Computation of Kinf for a dilute homogeneous   Bare Reactor

Material Description for Problem
  Fuel Material:                      U235/U238
  Fuel Density (g/cc):                 3.114e-004   ← from hand calc (this was for k=1.0)
  Fissile Enrichment (w/o):           100.000
  Moderator Material:                 C-12
  Moderator Density (g/cc):            1.600
  Temperature of fuel/mod mix (C):    20.000

Calculated Parameters for Kinf
  kinf =  1.372   ← 1.368 by hand
  eta  =  2.065   ← same
  f    =  0.664   ← 0.663 by hand
  pe   =  1.000

Some Additional Material Data
  Sffiss (1/cm) =    4.051e-004
  Safiss (1/cm) =    4.751e-004
  Safert (1/cm) =    0.000e+000
  SaF    (1/cm) =    4.751e-004
  SaM    (1/cm) =    2.400e-004
  DM     (cm)   =    8.400e-001
  LT2M   (cm^2) =    3.500e+003
  TAUM   (cm^2) =    3.681e+002
  MT2    (cm^2) =    1.543e+003
  DR     (cm)   =    0.000e+000
  LT2R   (cm^2) =    0.000e+000

    Computation of Keff for above   Bare Reactor    System

System Description
  Geometry Type:            Cartesian Geometry (XYZ)
  Core Dimensions (cm):     200.00 100000.00 100000.00
  Core Vol (cc):             2.000e+012
  Fuel Mass (kg):            6.228e+005
  Reflector Savings (cm):    0.000e+000
  Buckling (1/cm^2):         2.381e-004   ← same as hand calc

Calculated Parameters
  Non-Leakage Probability:  0.731
  Keff:                     1.003   ← 1.000 from hand calc
```

not bad!!!

note: difference in last digit is due to round off in hand calcs.

this works!

Prob 6.25

Given: Cubical bare reactor with homo mixture of U235 + graphite

$N_F / N_m = 1.0 \times 10^{-5}$

$T_F = 250\,°C$ } be sure to treat this properly

use modified 1-group theory

(a) Calc the critical dimensions

$$B^2 = \left(\frac{\pi}{a}\right)^2 + \left(\frac{\pi}{b}\right)^2 + \left(\frac{\pi}{c}\right)^2 = 3\left(\frac{\pi}{a}\right)^2 \quad \text{since } a=b=c$$

but $k_{eff} = 1 = \dfrac{k_\infty}{1 + B^2 M_T^2}$

$$\therefore \boxed{B^2 = 3\left(\frac{\pi}{a}\right)^2 = \frac{k_\infty - 1}{M_T^2}}$$

Thus, given the material composition, we can compute k_∞ and M_T^2 and then find "a" for the critical system.

Gather some data

at $T_0 = 20°C$ $L_{Tm}^2 = 3500\ cm^2$ for graphite (Table 5.2)

$\tau_{Tm} = 368\ cm^2$ for graphite (Table 5.3)

but $L_{Tm}^2(T) = L_{Tm}^2(T_0)\left(\dfrac{T}{T_0}\right)^{m+1/2}$ where $m=0$ for graphite

$$= 3500\left(\frac{250+273}{20+273}\right)^{1/2}$$

$$= 3500\left(\frac{523}{293}\right)^{1/2}$$

$$= 3500\,(1.336) = \boxed{4676\ cm^2}$$

$$\tau_T(T) = \tau_T(T_0) = 368\ cm^2$$

at $T = 250°c$ $\quad \eta_T = 2.058$ for UO_2 $\quad$ } interpolated within Table 6.3

at $T_0 = 20°c$ $\quad \sigma_{aF} = 687\ b$ for UO_2 $\quad$ } Table II.2

$\sigma_{am} = 3.4 \times 10^{-3}\ b$ for C-12 } Table II.3

$N_m = 8.023 \times 10^{-2}\ at/b\text{-}cm$

and with $\frac{N_F}{N_m} = 10^{-5}$ $\quad \boxed{N_F = 8.023 \times 10^{-7}\ at/b\text{-}cm}$

Now $\bar{\sigma}_a = \frac{\sqrt{\pi}}{2}\, g_a(T)\, \sigma_a(E_0) \left(\frac{T_0}{T}\right)^{1/2}$ $\quad$ } $g_a(T) \simeq 0.942$ from interpolation in table 3.2

$$\therefore\ \bar{\sigma}_{aF} = \frac{\sqrt{\pi}}{2}(0.942)(687)\left(\frac{1}{1.336}\right)$$

$$= \boxed{429.3\ b}$$

$$\bar{\sigma}_{am} = \frac{\sqrt{\pi}}{2}(1.0)(3.4 \times 10^{-3})\left(\frac{1}{1.336}\right)$$

$$= \boxed{2.255 \times 10^{-3}\ b}$$

1.0 for dilute homo sys't

Now we have $k_\infty = \eta_T f (p\epsilon)$

where $f = \frac{\bar{\Sigma}_{aF}}{\bar{\Sigma}_{aF} + \bar{\Sigma}_{am}} = \frac{N_F \bar{\sigma}_{aF}}{N_F \bar{\sigma}_{aF} + N_m \bar{\sigma}_{am}}$

$$= \frac{1}{1 + \left(\frac{N_m}{N_F}\right)\left(\frac{\bar{\sigma}_{am}}{\bar{\sigma}_{aF}}\right)}$$

Note $\boxed{Z = \frac{f}{1-f} = 1.89}$

or $f = \frac{1}{1 + (10^5)\left(\frac{2.255 \times 10^{-3}}{429.3}\right)} = \frac{1}{1.5253} = \boxed{0.656}$

and $k_\infty = \eta_T f = (2.058)(0.656) = \boxed{1.350}$

also

$$M_T^2 = L_T^2 + \tau_T$$

$$= (1-f)\,L_{Tm}^2 + \tau_{Tm} \quad \Big\} \text{ of aggregate + amps}$$

$$= (1-0.656)(4676) + 368$$

$$\boxed{M_T^2 = 1977 \text{ cm}^2}$$

Finally we have all the elements to compute B^2

$$B^2 = \frac{k_\infty - 1}{M_T^2} = \frac{1.350-1}{1977}$$

$$\boxed{B^2 = 1.770 \times 10^{-4} \text{ cm}^{-2}}$$

and

$$a = \sqrt{\frac{3\pi^2}{B^2}} \quad \text{for 3-D cubical bare reactor}$$

$$= \sqrt{\frac{3\pi^2}{1.770\times10^{-4}}} = 409.0 \text{ cm}$$

account for extrapolation distance

now $a_0 = a - 2d = 409 - 2(2.13)(0.84) = 405.4$ critical size

d ← 2.13 cm; 0.84 ← Table 5.2

$$\therefore \boxed{a_0 = 405.4 \text{ cm}}$$

(b) Calc critical mass

$$\text{Vol} = a_0^3 = (405.4)^3 = 6.663 \times 10^7 \text{ cm}^3$$

$$N_F = 8.023 \times 10^{17} \text{ at/cm}^3$$

$$\therefore m_F = \left(8.023\times10^{17}\,\frac{\text{at}}{\text{cm}^3}\right)\left(\frac{235.04 \text{ g } U235}{0.6022\times10^{24} \text{ at } U235}\right)\left(6.663\times10^7 \text{ cm}^3\right)$$

$$m_F = 2.086 \times 10^4 \text{ g} \Rightarrow \boxed{m_F = 20.86 \text{ kg}}$$

← critical mass

(c) If $P = 100$ kW, what is the max thermal flux.

$$\phi(x,y,z) = A \cos\frac{\pi x}{a} \cos\frac{\pi y}{a} \cos\frac{\pi z}{a}$$

where $A = \dfrac{3.87P}{V \kappa \bar{\Sigma}_f}$

and $\bar{\Sigma}_f = \frac{\sqrt{\pi}}{2} g_f(t) N_F \sigma_f \left(\frac{T_0}{T}\right)^{1/2}$

but $\sigma_f(E_0) = 587.\ b$ for U235 | Table II.2

$g_f(250°C) = 0.936$ for U235 ← Table 3.2 ½ interpolated

$\therefore \bar{\Sigma}_f = \frac{\sqrt{\pi}}{2}(0.936)(8.023\times10^{-7})(587)\left(\frac{293}{523}\right)$ Temperature corrected

$= \boxed{2.924\times10^{-4}\ cm^{-1}}$

$\therefore A = \frac{(3.87)(10^5\ J/s)}{(6.663\times10^{-7}\ cm^3)(200\ MeV)(1.602\times10^{-13}\ \frac{J}{MeV})(2.924\times10^{-4}\ cm^{-1})}$

$\boxed{A = 6.200\times10^{11}\ n/cm^2\text{-}s}$ ← max Thermal flux

assumes negligible fast fission

not enough info to get Σ_f.

Solve Prob 6.25 in Lamarsh using DILUTEH.M

Data Needed:

Reactor Type : Bare
Fuel Matl : U235/U238
Fuel Density : 3.13×10^{-4} g/cc

Note: The problem gives $N_F / N_m = 1.0 \times 10^{-5}$

But nominal density of graphite is 8.023×10^{-2} at of C-12 / b-cm

$\therefore \quad N_F = 8.023 \times 10^{-7}$ at of U235 / b-cm

$\rho = 1.6 \frac{g}{cm^3}$

and since $N_F = \rho_F \times \frac{N_A}{M_F}$

we have $\rho_F = \frac{N_F M_F}{N_A}$

or

$$\rho_F = 8.023 \times 10^{-7} \frac{\text{at of U235}}{\text{b-cm}} \times \frac{10^{24}\ \text{b}}{\text{cm}^2} \times \frac{235.04\ \text{g of U235}}{.60225 \times 10^{24}\ \text{at of U235}}$$

$$\Rightarrow \boxed{\rho_F = 3.13 \times 10^{-4} \frac{\text{g of U235}}{\text{cc}}}$$

Fissile Enrichment : 100%
Moderator Matl : C-12
Moderator Density : 1.6 g/cc
Temperature : 250°C

Geometry : XYZ
Dimensions : cube ⇒ all same { search for this value

→ see printouts (results are very close to hand calc)

critical size $a = 404$ cm { vs 405.4 cm (not bad)

critical mass $M_F = 20.64$ kg { vs 20.86 kg

(diluteh) (hand calc)

↑ These in code gave $k = 1.001$ (OK)

```
    Computation of Kinf for a dilute homogeneous   Bare Reactor


Material Description for Problem
  Fuel Material:                      U235/U238
  Fuel Density (g/cc):                 3.130e-004
  Fissile Enrichment (w/o):           100.000
  Moderator Material:                 C-12
  Moderator Density (g/cc):            1.600
  Temperature of fuel/mod mix (C): 250.000

Calculated Parameters for Kinf
  kinf =  1.351
  eta  =  2.058
  f    =  0.657
  pe   =  1.000

Some Additional Material Data
  Sffiss (1/cm) =    2.918e-004
  Safiss (1/cm) =    3.436e-004
  Safert (1/cm) =    0.000e+000
  SaF    (1/cm) =    3.436e-004
  SaM    (1/cm) =    1.796e-004
  DM     (cm)   =    8.400e-001
  LT2M   (cm^2) =    4.676e+003
  TAUM   (cm^2) =    3.681e+002
  MT2    (cm^2) =    1.974e+003   <--- 1977 by hand
  DR     (cm)   =    0.000e+000
  LT2R   (cm^2) =    0.000e+000

    Computation of Keff for above   Bare Reactor    System


System Description
  Geometry Type:            Cartesian Geometry (XYZ)
  Core Dimensions (cm):     405.40 405.40 405.40   <- from hand calc
  Core Vol (cc):             6.663e+007
  Fuel Mass (kg):            2.085e+001
  Reflector Savings (cm):    0.000e+000
  Buckling (1/cm^2):         1.770e-004

Note that a=b=c = 404 cm
gives k = 1.000 in the code
pretty close

Calculated Parameters
  Non-Leakage Probability:  0.741
  Keff:                     1.001   — very close to 1.0
```

P6.32

This problem is related to Problem 6.32 in Lamarsh (3rd Ed.). However, you should do the critical size calculations for both bare and reflected semi-infinite slab reactors. Note that, for the reflected system, the infinite reflector is water. Assume modified 1-group theory for the critical size calculations and use the correlation in eqn. (6.107) in your text to estimate the reflector savings for the reflected system. How do the critical sizes and critical masses for the reflected and bare cores compare? Is this consistent with your expectations? Discuss your results…

Note: This problem should be done by hand and with the **diluteh_gui** code.

Some needed eqns and data:

$$K_{eff} = \underset{\text{for critical}}{1} = \frac{k_\infty}{1 + B^2 M_T^2}$$

where

$$k_\infty = \eta_T f p \epsilon \simeq \eta_T f (1.0)$$ ← dilute homogeneous system

$$M_T^2 = L_T^2 + \tau_T$$
$$= (1-f) L_{Tm}^2 + \tau_{Tm}$$

$$f = \frac{\Sigma_{aF}}{\Sigma_a} = \frac{\Sigma_{aF}}{\Sigma_{aF} + \Sigma_{am}}$$

bare system $B^2 = \left(\frac{\pi}{a}\right)^2$ with $a = a_0 + 2d$ ← $d = 2.13\bar{D}$

reflected system $B^2 = \left(\frac{\pi}{a_0 + 2\delta}\right)^2$

where $\delta = 7.2 + 0.10(M_T^2 - 40.0)$ } eqn 6.107 in Lamarsh

core matl: $Pu239 + H_2O$ with Pu239 conc of 8.5 g/liter

$$\therefore N_F = \frac{8.5 \text{ g Pu239}}{1000 \text{ cm}^3} \times \frac{0.6022 \times 10^{24} \text{ at/gmole}}{239 \text{ g/gmole}} \times 10^{-24} \frac{\text{cm}^2}{\text{b}}$$

$$= 2.142 \times 10^{-5} \text{ at/b-cm}$$

$$N_m = \frac{1 \text{ g}}{\text{cm}^3} \times \frac{0.6022}{18} = 3.346 \times 10^{-2} \text{ at/b-cm}$$

$$\therefore \frac{N_F}{N_m} = \frac{2.142 \times 10^{-5}}{3.346 \times 10^{-2}} = 6.40 \times 10^{-4}$$ ← Thus, the assumption of a dilute homo system is indeed valid

for Pu239

$\eta_T = 2.035$ (from table 6.3) at 20°c

$g_a(t) = 1.0723$ (from table 3.2)

$\sigma_a(E_0) = 1020$ b (from table II.2)

$$\therefore \bar{\Sigma}_{aF} = N_F \bar{\sigma}_{aF}$$
$$= N_F \frac{\sqrt{\pi}}{2} g_a(t)\, \sigma_a(E_0)$$
$$= (2.142 \times 10^{-5}) \frac{\sqrt{\pi}}{2} (1.0723)(1020)$$
$$= (2.142 \times 10^{-5})(969.3)$$
$$\boxed{\bar{\Sigma}_{aF} = 2.076 \times 10^{-2}\ cm^{-1}}$$

for water

$\bar{\Sigma}_{aM} = 0.0197\ cm^{-1}$

$\bar{D}_m = 0.16$ cm

$L^2_{Tm} = 8.1\ cm^2$

(from table 5.2)

$\tau_{Tm} = 27\ cm^2$ ← (from table 5.3)

$\therefore$ Thermal utilization

$$f = \frac{\bar{\Sigma}_{aF}}{\bar{\Sigma}_{aF} + \bar{\Sigma}_{aM}} = \frac{2.076 \times 10^{-2}}{2.076 \times 10^{-2} + 1.97 \times 10^{-2}}$$

$$f = \frac{0.02076}{0.04046} = \boxed{0.513}$$

$$\therefore k_\infty = \eta_T f = (2.035)(0.513)$$
$$= \boxed{1.044}$$

$$M_T^2 = (1-f) L_{Tm}^2 + \tau_{Tm}$$
$$= (1 - 0.513)(8.1) + 27$$
$$= \boxed{30.94\ cm^2}$$

$$\delta = 7.2 + 0.10 (M_T^2 - 40)$$
$$= 7.2 - 0.91$$
$$= 6.294 \approx \boxed{6.3\ cm}$$

Okay, now we have all the info needed to compute the bare and reflected critical size

recall $$1 = \frac{k_\infty}{1 + B^2 M_T^2}$$

$$\therefore \quad B^2 = \frac{k_\infty - 1}{M_T^2} = \frac{1.044 - 1}{30.94}$$

$$\boxed{B^2_{crit} = 1.422 \times 10^{-3}\ cm^{-2}}$$

Bare Core

$$B^2 = \left(\frac{\pi}{a}\right)^2 \qquad a = a_0 + 2d$$

$$a = \sqrt{\frac{\pi^2}{B^2}} = 83.31\ cm$$

$$a_0 = a - 2d = 83.31 - 2(2.13)(0.16)$$

$$= 83.31 - 0.68$$

$$\boxed{a_0 = 82.6\ cm}$$ ← critical size

$$M_F = \frac{(82.6\ cm)(8.5\ g/cm^3\ Pu239)}{1000\ cm^3}$$

$$\boxed{M_F = 0.70\ \frac{g\ Pu239}{cm^2}}$$ ← critical mass (per unit area in yz plane)

→ see dilutch_slab1bare.txt

Reflected Core

$$B^2 = \left(\frac{\pi}{a_0 + 2\delta}\right)^2$$

$$a_0 = \sqrt{\frac{\pi^2}{B^2}} - 2\delta = 83.31 - 2(6.3)$$

$$= 83.31 - 12.6$$

$$\boxed{a_0 = 70.7\ cm}$$ ← critical size

$$M_F = \frac{(70.7)(8.5)}{1000} = \boxed{0.60\ \frac{g\ Pu239}{cm^2}}$$ ← critical mass per unit area

→ see dilutch_slab1refl.txt

Clearly these values are consistent with expectations — the reflected system should have a smaller critical size and critical mass.

```
    Computation of Kinf for a dilute homogeneous   Bare Reactor


Material Description for Problem
  Fuel Material:                        Pu239
  Fuel Density (g/cc):                 8.500e-003
  Fissile Enrichment (w/o):           100.000
  Moderator Material:                 H2O
  Moderator Density (g/cc):            1.000
  Temperature of fuel/mod mix (C): 20.000

Calculated Parameters for Kinf
  kinf =  1.044
  eta  =  2.035
  f    =  0.513
  pe   =  1.000

Some Additional Material Data
  Sffiss (1/cm) =    1.491e-002
  Safiss (1/cm) =    2.076e-002
  Safert (1/cm) =    0.000e+000
  SaF    (1/cm) =    2.076e-002
  SaM    (1/cm) =    1.970e-002
  DM     (cm)   =    1.600e-001
  LT2M   (cm^2) =    8.122e+000
  TAUM   (cm^2) =    2.697e+001
  MT2    (cm^2) =    3.092e+001
  DR     (cm)   =    0.000e+000
  LT2R   (cm^2) =    0.000e+000


    Computation of Keff for above   Bare Reactor    System
```

from hand calc

```
System Description
  Geometry Type:            Cartesian Geometry (XYZ)
  Core Dimensions (cm):     82.60 100000.00 100000.00
  Core Vol (cc):             8.260e+011
  Fuel Mass (kg):            7.021e+006
  Reflector Savings (cm):    0.000e+000
  Buckling (1/cm^2):         1.423e-003

Calculated Parameters
  Non-Leakage Probability:  0.958
  Keff:                     1.000
```

← gives critical system (OK)

```
    Computation of Kinf for a dilute homogeneous Reflected Reactor


Material Description for Problem
  Fuel Material:                        Pu239
  Fuel Density (g/cc):                 8.500e-003
  Fissile Enrichment (w/o):           100.000
  Moderator Material:                 H20
  Moderator Density (g/cc):            1.000
  Temperature of fuel/mod mix (C): 20.000
  Reflector Material:                 H20
  Reflector Density (g/cc):            1.00
  Temperature of Reflector (C):       20.00

Calculated Parameters for Kinf
  kinf =  1.044
  eta  =  2.035
  f    =  0.513
  pe   =  1.000

Some Additional Material Data
  Sffiss (1/cm) =     1.491e-002
  Safiss (1/cm) =     2.076e-002
  Safert (1/cm) =     0.000e+000
  SaF    (1/cm) =     2.076e-002
  SaM    (1/cm) =     1.970e-002
  DM     (cm)   =     1.600e-001
  LT2M   (cm^2) =     8.122e+000
  TAUM   (cm^2) =     2.697e+001
  MT2    (cm^2) =     3.092e+001
  DR     (cm)   =     1.600e-001
  LT2R   (cm^2) =     8.122e+000


    Computation of Keff for above Reflected Reactor System

                                        from hand calc
System Description
  Geometry Type:            Cartesian Geometry (XYZ)
  Core Dimensions (cm):     70.70 100000.00 100000.00
  Core Vol (cc):             7.070e+011
  Fuel Mass (kg):            6.010e+006
  Reflector Savings (cm):    6.292e+000
  Buckling (1/cm^2):         1.423e-003

Calculated Parameters
  Non-Leakage Probability:  0.958
  Keff:                     1.000  <- give critical system (OK)
```