22.06 **ENGINEERING OF NUCLEAR SYSTEMS**

QUIZ 1 1.5 HOURS

Name:

CLOSED BOOK QUESTIONS (20%)

For each of the following drawings, identify the components indicated by the red arrows and describe (in one sentence!) their function.

PWR

____ What is it ?

____________________________________ What is its function ?

____ What is it ?

____________________________________ What is its function ?

____ What is it ?

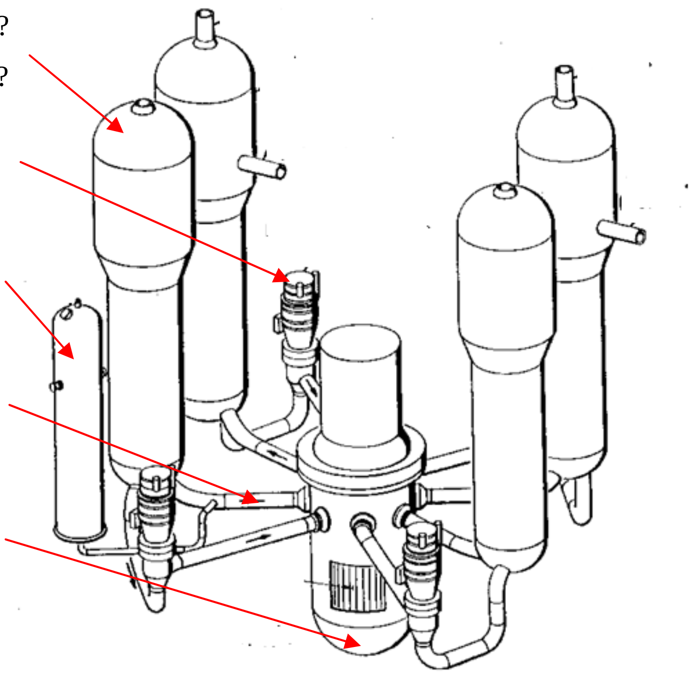
____________________________________ What is its function ?

____ What is it ?

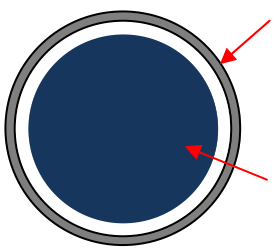
____________________________________ What is its function ?

____ What is it ?

____________________________________ What is its function ?



Cross-sectional view of a PWR fuel pin



What is it ? ____

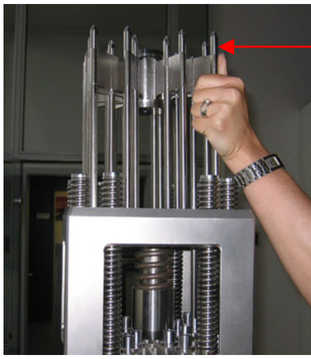
What is its function ? ______________________________________

What material is it made of ? __________________________________

What is it ? ____

What is its function ? ______________________________________

What material is it made of ? __________________________________

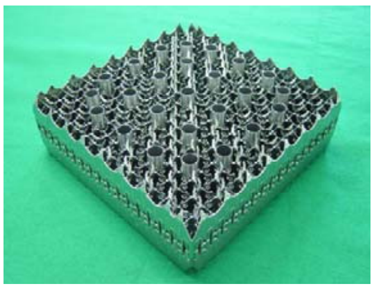


What is it ? ____

What is its function ? _____________________________________

What material is it made of ? _________________________________

Public domain image from wikipedia.

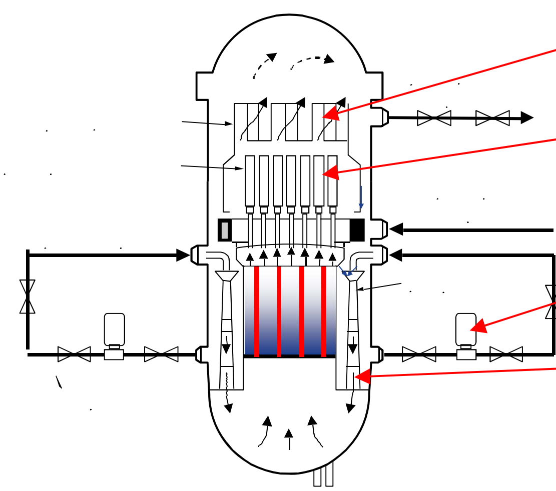


What is it ? ____

What is its function ? _____________________________________

What material is it made of ? _________________________________

BWR



What is it ? ____

What is its function ? _____________________________________

What is it ? ____

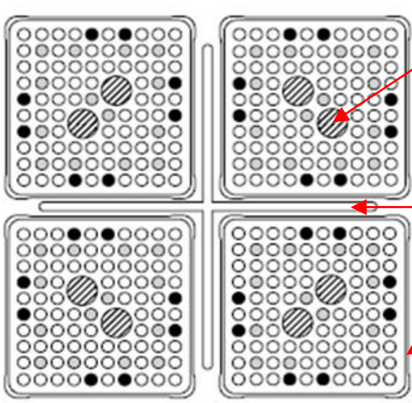
What is its function ? _____________________________________

What is it ? ____

What is its function ? _____________________________________

What is it ? ____

What is its function ? _____________________________________



What is it ? ____

What is its function ? _____________________________________

What is it ? ____

What is its function ? _____________________________________

What material is it made of ? _________________________________

What is it ? ____

What is its function ? _____________________________________

What material is it made of ? _________________________________

22.06 **ENGINEERING OF NUCLEAR SYSTEMS**

QUIZ 1 1.5 HOURS

OPEN BOOK QUESTIONS

Short Questions (10% each) (adapted from Shultis & Faw textbook)

a) A nuclear reactor in a submarine delivers 18 MW of shaft power (work) at a cruising speed of 20 knots (1 knot = 1.852 km/hr). If the power plant has a thermal efficiency (= work/heat) of 25%, how much (in kg) of the ^{235}U fuel is consumed on a 60,000 km trip around the world? In answering this question, make use of the following ^{235}U data: 200 MeV/fission, absorption cross section = 678 b, fission cross section = 577 b

b) Following a reactor scram, how long is it before the reactor power decreases to 0.5% of the steady-state power prior to shutdown? You may assume that the reactor had operated for an infinitely long period of time prior to shutdown.

c) A small homogeneous sample of mass m with atomic mass A is irradiated uniformly by a constant neutron flux ϕ. The microscopic scattering cross section for the sample material is denoted by σ_s. Derive an expression for the time it takes all nuclei in the sample to scatter once (on average) with the neutrons. State any assumptions made.

Problem 2 (50%) – Temperature distribution within a fuel pellet with non-uniform heat generation (adapted from Duderstadt & Hamilton textbook)

The neutron flux depression within a cylindrical pellet can be modeled by assuming that the radial dependence of q''' is of the form $q'''(r) = q_0'''[1 + a(r/R)^2]$, where q_0''' is the volumetric heat generation rate at the pellet centerline, r is the radial coordinate within the pellet, R is the radius of the pellet, and a is a constant.

i) Derive an expression for the linear power in the pellet, q', in terms of q_0''', R and a. (10%)
ii) Derive an expression for the centerline temperature as a function of the constant a, the linear power q', the fuel thermal conductivity k_f, and the fuel surface temperature T_{fo}. (25%)
iii) Compute the centerline temperature for the following values of the constants: a=0.12, q'=25 kW/m, k_f= 3 W/m-K and T_{fo}=400°C. (5%)
iv) Compute the centerline temperature for the case of uniform heat generation rate and the same values of q', k_f and T_{fo}. Explain physically any difference you may see between the results in 'iii' and 'iv'. (10%)