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PRNC 17

PUERTO RICO NUCLEAR CENTER

PROGRAM OF INSTRUCTION

FOR PRNC REACTOR OPERATORS

(Academic Phase)

---Page Break---

PROGRAM OF INSTRUCTION

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PUERTO RICO NUGLEAR CENTER

REACTOR OPERATORS

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course

PURPOSE

PREREQUISITES

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TRAINING LOCATION

SECTION T - PREFACE

RNC REACTOR OPERATORS COURSE (Academie Phase)

To provide reactor operator trainees with th
scaUomic preparation necessary for further
technical instruction in the operation and
maintenance of PRNC research reactors.

?Adntesion to the PRNC Reactor Operators

Training Course

6 months

Puerto Rico Miclear Center - Mayaguaz

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SECTION Ir - sumuay

PRIG REACTOR OPERATORS COURSE (Academic Phase)

Time:

Sub.

Acadente Sub jecte

Mathenatice and slide Rule

Physics

Nuclear Engineering

Hectro-Hechanical Engineering

Health Phys:

and Chemistry

Plant Information

Type of Instruction

Lecture L

Demonstration >

Conterence e

Practical Exercise PE.

Examination z

6 months

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Annex

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FRNG REACTOR OFERATORS COURSE (Ac

SECTION ILI - Bove

lente Phase)

ACADEMIC SUBSECTS

Thom, 356 hours

subset sc ANNEX HOURS PAGE

MATHEMATICS

FaYSICS

NUCLEAR ENGINEERISC

RLECTRO-NEGHAWICAL

ENCINEERTNG

Algitraie operations; alge: 1 n

logarickes

exponentials; trigonce~

etry and vectors} sizee tu!

J operators; exersnation

Basie machanics, work. power, 2 a

and energy; atonte physics

and radicactavity; baste i

distion detection, ausiear

Fhysice; examination, Lats

retort

fcactor physics; steady state 4 ?

analysis; transient analyats;

Basic flatd dycantes ané pespay

rower plant soapencate, cater

rials and practices; baste

therscdycinies; exaninat ion;

Lsberatortes.

Téfects ef sontetng racterion; 38

stancards of radlological pro-

tection; applied hesith phystes

chenrstey and feedwater trsat=

Bent; examination; laboratories.

Introduction and generei plant

features; primary aystent

secondary syszens; dvartnation

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---Page Break---

PURPOSE: To give rhe studant matheuatical ability in basic arithzettc opers

SECTION 1 - AMES

ANNEX NOGER 1

Machentice and Slide Rule

Time: 71 hours

Hions, algebra, trigonometry, vectors, logarithas; 10 reach seadents

sige ?rule operations required for the solution of applied problems

in other academic subjects.

HOURS. AND

suesect SCORE TYFE

core

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course Introduction te eubject; use of Lt

Introduction Liveral sumbers; defination of

algebraic terns and notations;

terms and factors; signs of

grouping.

Arithmecte Review of methods in sedition, aL

Panctions 1 fatetraction, multiplication of

arithmetic functions ; eimplits

ation of complex fractions ;

operations with porieive, regs:

ive nusbers, with rere.

z Introduction to the sitée rule; Lue

Reading thw 61

"DU acalee; "CL" and "DL" scalze.

Law of

expenses multiplication, and division of

Hon, substraction, ab

Radicals Definitions; ccaversion from LL

?exponential to radical fore;

factoring and renoval of factors

from the radical; addition,

speraction, mitipltestion of

radicals.

slide Rule 11 Simple multiplication on the "C 1 Pe

nd "D" scales. "Cl" end "DL"

scales, Ratio and proportion

ssvolving "C" acd "DY acalan,

Bxponenty ene Practical sxarctae involving Le

radicale materiale covered ta houre 4 and

5

---Page Break---

OURS AND

supsect S00FE, TE

es sore ee

8 Multiplication of Multiplication of positive and negative ie

nocoeisis end Pumbera; multiplication of moncmisis

aad polynoatal

9 Slide Rule TIT ?Multaplication of musders involving ure.

the use of powers of ten,

10 Mulesplication of Practical exercives ard review of ee

worentals and ateriel covered in hour No. 3.

polynoatals

Li vivisten of Division of monomiele and polyzontale iL

Horomia axé by monomtals and polynonia!

12 Slide Role Division tavolvicg wie of "Cc", "DY, Lue

"ci" and "DI" scales usa of ratio

acd propertien and pover of ten.

13. Division of Fractical exarcises and review of 1 Pe

Menomtaie and material covared in hour No, LL.

Foiysomiais

16 Spectat Froducte Squaring binomtala; product of eum iL

and Fascoriag I and difference of tuo terms; product

?of any wo binomials,

15 spectal Produces Factoring polysomtals with comon iL

factors, diffcrence of tro squares,

varios trisonials, som and differs

ence of tye cubes

16 Spectal Products Practisel exarctees and review of lee

and Factoring IIT material covered in hours to. 24

and 15.

" Reduction of Liceral fractions and ak

zixed expressions by lowest common

Gerominatoe

8 Addition, aubtraction, milttplicetion iL

ané division of Literal fractions;

complex fractions.

& Practical exerciee in reduction of LPE

Fractions

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HOURS AND

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Examination 7

Slide Rule ¥

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Linear Equa

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Practical evercives and review of

materiel covered in hours No. 20

and Zl,

Review of material covered in houre

Wo. 1 to 21.

Exautnation on material covered in

hours No. 1 to 21.

Combines operations of multiplice
ion and division involving "Cc"
"Ci" and "DI" ecales and povers
of ten,

Definitions; aqvations, indectities
and conditionsl equations axioms in
operations with equations; rules of
transposition, carcelling, changing
of wigs

Checking of equstions, practical
the solution of linear

ye cd TAN, 8 and ett

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Frinciples of

interes

snd slope, eolatione of sumite

peux Lister equatises.

Frectical exercises and review of

material covered in hour ¥o. 28

Raising acy suaber to any pover,

Using LL and LEO scales. Comparison

with MAM, "BM, and "R" scales

Algebraic solution by addition and

sober

Solution of eqsations containing

cares unknowns.

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Equations

Radical

Equations

Literas

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Definitions

Trtgoncacris

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?ttonsl equations,

Solution of radical equstions.

Solution of quadrette squatioas.

Frectical exercise tn the solution

of fractional, radical and quadratic

equations,

Solution of itteral equarices stutler

$2 thoes encountered dn other ace-

Practical exerctees and review of

saterisl covered in hour No. 28.

Review of materisl covered in houre

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Introduction co crigonometry deft

aition of angle; coordinate syeten

tngler etailar right

sition of basis foncticrs; ne

Froval functions of the same esgle;

Confunctions of the conplemnctty

augie. Basic definitions of fune-

ttons of acy angle.

Use of tables and siide rule to find

the 5 © angle. Discussion

at, cosine, tangent vary

Shrough the use of the uate circle.

Use of the lige rule tavolving the

site ane cosine sealer,

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Right Triangle:

slide Rule x

Periodic Func

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Exanination 121

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Logarithes

Slide Rule x27

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Equat sons

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Review Class

Tramination 1

ton of the right

angle,

ution of the right triangle oo

slide role

Rotation of the watt circle: graphs of

the ertg. functions.

Geceral sine vave equation; angular

wotien; oscillatory notion; rotery

wetion,

Review of material covered in hours

42'te si.

Examination o materiel covered ia

fours 42 t0 Ste

fniticn of logerithe use tn mult:

wien, division, and raising to

Power,

Base 10 Logartthns; manti.

characceristis,

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Practical exercise involving eaterial

severed in hours 54 and $5.

Precticel exercises tn vie of MLM

Pate "eh logartthna; finding natural

loge wrirg "EL" scales ca eltde rule.

Siiée rule profistensy test

Solution of logarithate and ecponential

equesions. Crapke of Logarithats fone-

tions; sclutione of growth ard decay

relecionships

Advastages of semt-leg and log-log

grap? paper and comperizon te linear

Plot. ?Plotting of e¥ endo?,

Review of material covered in hours

5 te 61,

Exantnation on material covered in

hours $4 te él.

---Page Break---

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Plane vectors 1

Plane Vectors IT

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3 Operator

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Review Class

Exanization ¥

Ekattions; eaphar

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Vector aubtraction; componente of «

verter, addition of rectarguler

couparants.

"of vector problems,

Real and tnaginery cusbers, complex

sombers; grapaical represeatation of

sumbers affected by 3) fundamental

?operations vith complex auxbers,

Graphical representation of adéttion

aubtrastion, multiplication ant

division of sompiex mmbere; polar

form of complex tubers, multipli-

cation and division of complex nose

bers in polar form

Practical exercise involving material

covered in hours 67 and 62

Review of material cove

papeatry

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Exantnacton in material cove

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PURPOSE:

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Introdvetion and 1k

physics necessary for o detail

ANNEX SINGER 2

Pavsres

Time: 61 hours

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study of nuclear reactor sngineeriog

and beaith physicy

CGS aysten

Linear Motion

Rotary Motion

Force, work and

power?

Energy 1

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Energy t1t

Eoergy 1¥

Exentnation 1

Matter and

Molecules

Anporcance, objectives proce:

G5 unste Of ease Length, cine,

force, work, and power,

Weloctty-tine-dtstance relationship,

ity, momentum and

Redion, angular velocity, and

scceleretson.

Review motion, force, work, power,

unite, equivalence of work and exargy

change,

Heat energy acd temperature, theory,

waits, temperature scales oad

Elecerto energy, electrostatic force

sad potential, reference to EE, electron

Chestcei aed cuclear energy, comparison

of nergy release, reaction equations,

acd magnitudes

All materials from 1 co 8,

Fropertios of water including states,

density, composition, division of

Water ?cto selesules compounds ead

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Atomic Nuxber

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Radioactivity T

Radionctivity 11

Radioactive Decay

Chart of the

Muclides

Radioactive Decay

Series

ha and Beta

Pereicies

soma Rays and

Nevtrone

Interactions of

Particles

Interaction of

Radiation vith

Matter

Identification of elements, chenicat

symbols and periodic table; electrons,

protons sod neutrons; electrostatic

forces

Models of Thompson, Rutherford, Bohr,

Bobr Summerfield, iyperfine, aad Modern,

tionship to nunber of protons, elec

Erons 2 x 4'mase of natural atoms, teo-

topes, Lecbars, isomers nuclear reaction

equation.

Einstein's equation, calculations amu te

@ conversion, suclsar reactions equations.

Mase of constituents ve, masa of result

relationship of

ALL sateriais from 11 to 16,

Introduction te radioactivity, both

Barural and artificial; propertics of

rastat ten,

Denosttration of physical phenomene.

Statiarics of ratioaceive decay, half Life,

Gecay constant, laws of exponential decey.

Use of Chart of Muclides in radioactive

decay ans ruclear reactions.

?Farentedaughter decay series, naturel and

areificiel seri

Charge ané mass; typical alpha and bere

decay; range in atr; equation; energy;

Charge and masa; other electromagnetic

radiation; range; wave length; frequency,

Flanck's constant, energy.

Tons! electrostatic attraction and repul-

Sion; speciiic tonization va. pathlength;

Fhotovelsctric effect, Compton scattering,

Pair production; annihilation radiation.

---Page Break---

2

HOURS AND

super SCORE TEE

26 detection 1 Principles of operation of tontzation iL

chasber, proportional counter.

27 detection 11 Feinciples of operstion ef UIC, crc, aL

BF cetector, and fiveion chenber-

28 Radiation Atte- Tine and distance; radioactive decay, aL

nuetion I inverse square Law,

2 Attensétion by Material effect on attenuation, atter aL

Materials mustion coefficient; exergy and material

dependence; half thickness.

30 Review ALL material from 19 to 29 le

?SL Examination TIT All materiel frow 19 to 29 ie

Review properties of neutrons; absorption, 11.

scattering, Easton,

33. Flux Beam flux; reactor flux; concept, unite, at

relation to intensity

34 Reaction Dependence of cross eection on projectile aL

Cross Section I energy; target muclene, end specific

reactions,

35 Reaction Microscopie and Macroscopic cross it

Cross Section IZ sections

26 Reaction Rate Dependence on flux and microscopic cross iL

section; sample calculation

37 Moocfission ab~ Conditions leading to non fission absorption; 11

sorption of activation; applicability to reactors

38 Neutron Woters- Elastic and inelastic scattering; conser- in

tion ation of nomeatum and KE} necessity of

moderation, properties of soderator

Physical events during moderation,

H Conditions Leading to fisnion; liquid drop LL

model; threshold energy; the fiseionable

raclides used is reactor

40 Neutron Physics Review physical avents during moderation; iL

Antroduction to eutron Lifetime, fermi

faze <iftusion Length, migration area.

---Page Break---

OURS AND

sussecr Score, mu

Smee score ee

41 Examination ALL material covered in 1 co 40 2

42 Boyle's Law and Behavior of under verying conditions;

Charles? Law Antroduetion to lab. procedures and graph=

ing experimental results,

43 ?Statistical wa- Use of acalers, and determination of desin- 4 PE.

ture of Radio- tegration probabilities of radioactive

activity sources,

46 Radiation Use of G.M., proportional counters, actin ame

Measurements Esllation and BFs detectors. Voltage

plateau determination.

43 Radioactive Decay Determination of half-1ife and decey ore

constant

46 Gama Shielding Shield effectiveness of various materials; 4 PE

attenuation coefficients

---Page Break---

PURPOSE: To give the student an underst:

theory and related fundamental

ANNEX NIMBER 3

NUGLEAR ENGINEERING

?Time; 66 hours

study of plant operations.

sonable

Materials

2 Fiseion Process

land Chain Reas-

fon

3 Neutron Ceo

Sections and

Reaction Rate T

4 Weutron cross

Sections and

Reaction Rate 11

3 Fission Neutrons

© Neutron Generation

Tine and Lifetime

7 Nevtron Travel

8 refintee Multi-

plication

Introduction. Names and synbols of

prime fiesionsble materials, fuel

enrichnent.

Liguid-drop nuclear model; conditions

required for fission; release of

energy in fission; fission product

distribution. Chain reaction: no

sustaining, sustaining, multiplying.

uate

fasion and capture cross sections of

rector materials,

Practical exercise in the use of reac-

tion probsbilities end cross sections.

Neutron energy spectrum; prompt and

Selayed neutrons; decay of delayed

neutron precursors. Definition of

beta, the delayed neutron fraction,

Neutron Lifetine; effective neutron

the effecte of

nevtrona upon overall

tion time; influence upos reactor control,

Derivation of average logarithnic eneray

decrement; moderator slowing down power,

moderating ratio; feroi age, slowing dom

Length; diffusicn laagth; migration eres,

migration length.

Definition of keg, the multiplication

factor. Introduction to the four factor

formula, Calculation of four terms from

the reutren cycle,

?

anding of the basic nuclear reactor

Procedures essential for a detailed

?HOURS. AND

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Nestron Prodve:

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Resonance Fs: aps

and Thereal tei-

Lization

Fast and Thermal

Leakage

Geometric Buckling

Exanteatton 1

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Moltéplication 11

Multiplication G27

Reactivity coef

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Score,

Definition and derivation of reproduction

dependence of eta upon fuel
ferichtent; definition of fast fission
factor; dependence of epsilon upon earich=
went, ratio of fuel to moderator, anc eshor
reactor paransters.

Definition of resonance escape probability;
gontrol of p through moderator/fuel tatis,
fuel absorption cross ssction, aves
dogerithaic energy éccrenant of nodefator,
farichment; definition and derivation of
Ehermal utilization factor, influence of
oderator/fuel racic.

Foe finite reactor; definition of keee.
Definition and mathometical expressio? of

fast and theraal neutron nonleskage prosa-
bilities; solution of materials Duckling,

Geometric buckling) relationship between
materials and geometric buckling; samp
saloulation of core critical atte,

Examination on material covered from
Teo 12,

Review of sultiplication factor. Deri
vation of neutron multiplication equation;
sample calculations.

Derivation of neutron multép!ication
suation; discussion of equation ascimp-
tions and Limitations; review of efter
tive neutron generation tine.

Definition of reactor period. Derivation
of nevtron miltiplication equation defte
piston of reactivity; graph of reactivity
Yi. Period; relationship beteren reace
tivity and effective nectron generstion
tise,

Temperature coefficients of rea
nuclear coefficients dus to changes in
Géftusion length, fermi ag:

cross sections, and dorpier
sity coeffictents dee to changes in
sactoscopic orcas sections, buckling, and
rector dimensions.

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Reactivity coef

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Poisons T

Potsons 11

Control Rod

Effects

?Transient

Effects

Examination 11

Flx control

Reactor instru

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Reactivity

Costficience

Reactor Poel

Elements

Pressure, vosd and poison coefficients of reactivity; effects upon reactor operation; fuel loading requireesats te compensate for negative reactiviey eftacts,

Origin of fission product potsone; quali-tative and mathematical descrigtion ot the rate of buildup and renoval of xeson Poison; equilibrium concentration.

Mathematical derivation of the reactivity equivalent of reactor polson from che Anfivence of poisons upon thermal utild-sation factor. Sample calculations.

Effect of control rods; perturbation of

Fesctor flux; use of control rods to some

Panvate for negative reactivity effect.

and changes in power; shadowing sffest

introduction to rod vorth.

Seview of transient anatysis: multspli-

cation equations, reactor period, ©

tivity and reactivicy costficienta, flux

Perturbation; delayed ceurron transtents,

Examination of eatertal covered from

16 to 22,

Types of control rode; genersl features

of reactor control; acrans, Seckests

interlocks; function of the cpersece.

Types and ranges of reactor flux moaitor-
Seg inetronents; uses during operat iony
startup; linear power, log n, ported aad
Fower channels, principles of design.

Reviaw of princtples of Control rod worth;
experimental procedure for worth determi.
nation; sample calculations.

Experinental procedure for detereination
of tenperature and poison coefficient
?sample? calculations,

Types ane Lunetions of reactor fusl
slenents; Esbrication principles; burnable
potsens,

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OURS AND

supsecr SCOPE, Tue

29 Heat Transfer 1 of heat transfer; conduction, LL

convection, radiation; temperature vers

heat transfer curves; mscleate bofling

30 Heat Transfer IT Reactor heat sources; dependence upon iL

flux, hot spots; shstdovn heat sources,

Yenoval of decay heat.

31 Reactor actor accident conditions; scram pare- at

Management, eters an¢ bypasses; design considerations;

maximum credible ascident; radiation

hazards tn plant location and gafeey.

32 Examination IT] Examination on materiel covered from le

2% to 31.

33 Reactor Shielding Review of particle and ray attenuation; ab

types and effectiveness of ahtelding

aterials; renoval of heat from ehield.

34 Reactor Materials Types of reactor coolants; cheracteristics 12

1 Of various coolants; selection eriteria;

moderating and reflecting materials.

935 Keector Materials Reactor atructural materials; other iL

0 materials assoctsted with reactor com

Ponents; corrosion, mass traceport

36 Reactor Regtation effects upon rexctor materials, lt

Materials 12 aztivation; nul-ductility transition

temperatures; curves of operating Limite.

37 Reactor Loop Conponents peculiar te reactor aystene; ab

Components Piping requirements zero Leakage pumps

?and valves; leakage contro! systees;

purification systems.

38 Suberietcal Derivation of mathematical expression for LL

Multiplication neutron suber{tical multiplication; sigei-

ficance of multiplication, reactor neutron

sources; startup procedures

2 Core Leading Sore loading procedures; taverse mlti- iL

plication curves, significance, applic

tion to loading of fuel storage areas

40 startup Approsch to criticality; etarrup procedures; 1 1.

Operations ?hazards involved in inpropar operation.

---Page Break---

HOURS AND

SUBJECT Score Tre

41 Power operation Reactor operation at pover; important iL

and Shutdown system parazaters; shutdown conditions

review of nuclear reactor engiceering,

42 Examination Iv Examination on material covered from 28

33 to 41.

43 Neutron Phenomena Denonstration covering moderation, ome

reflection, diffusion, and other

neutron phenomena.

44 Introduction to General introduction to nuclear simlator, 3 PE

Nuclear Similater operation of aimilator, and description of

component.

43 Reactor Startup _Familfarization with reactor startup pro- 3 re

cedures and transient Behavior during

startup,

46 Reactivity v Bffects of radioactivity changes on 3 re

Period reactor period, graphing reactivity v

period curves,

47 Control Rod Reaceivity worth calibration of control 3 PE

calibracton rod.

48 Poison Effects Effects of Xenon and other poison on oe

on Reactivity reactivity.

49° core Loading Core losding procedures, ?averse 3 Re

multiplication.

50 Automatic Requirements for automatic controls, 2 Pe

Controls demonstration of

---Page Break---

8

AOWEX NBER 4

ELECTRO-MECHANIOAL ENGTNEERING

Tine: 26 hours

PURPOSE: To give the students an underatending of electric etreuits found in

electrical and electronics fields and to provide the students with

sone understanding of fluid flow and heat transfer and of components

found in nuclear reactors

HOURS. AND

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met _____soom ve

1 The Sinple Outline of course; Ohms Lav, power, at

Electric ?sample problens.

chresie

2 Do series Kirchoff's voltage law, application iL

Circuits of Ohn's and Kirchoff's lava to DC

series circuits.

3° Dc Parallel Kirchoff"s current lev, application of lL

Chreuits Ohm's and Kirchoff"s laws to DC

parallel cireuie:

4 D.C Compound Series-paraliel combinations, simplift aL

Circuits cation and solution of compound circuits,

voltage dividers,

3 Dc cireute Student solution in class of DC etreuit 1 PE

Probiens problems.

6 Electricat Wire measurenent, resistivity, ingulation, = 11

Conductors protection.

7 Review of Dc Examination on material covered from le

Theory Vite 6,

8 Alternating AC definitions, vectors, sine wave iL

Current. characteriatics

9 Teduceans Self inductance, induced emf, mutual in

inductance, phase relations, ?time

29° Capacitance Capacitor construction, dielectrics, aL

time constant, phase relations

11 Inductive and Phase relations between voltage current in

Capacitive Am reactive circuits, vector problems;

Rea

impedance

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AC Power

Ac Series

Chrevies

?Ac Parallel

Chreuies

AC Composé

Circuits

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Electrical

Indicating

Instruments

Review of AC

Theory

Beaninstion IE

Tubes snd Current

Conduction

Unisirectional

Devices

Power Supplies

Power supply

Waveforss

Axplification tm

Vacuum 3254

Gae-Fiited Tebes

+ syachros

Review

Examinstion 11

Tracsforsere

COPE

?True power, reactive power, apparent

power, power factor, power crisngle,

Solution of series circuits contetniny

resistance, inductance, and capacitance.

Solution of parallel circuits containing resistance, inductance, and capacitance.

Solution of compound circuits with complex branches,

Stadents solve AC problens in class,

D'Arsonval galvanoneter, ameter, volt meter, shunts and multipliers, elestro-aynanoneter.

Review of all material cove

sa 8 to 17,

Examination on saterial covared in 8 to 17.

?Tube types; electron entssion,

Vacuum diodes, crystal diods rectifiers.

ary disk

Purpose, components, filters, waveforms.

Demonstration of half and full wave reetifi-

cation with various filters

Fundamentals of vacuum triode amplifiers

Gas diodes, chyratrons, phototubes, applica

tion of synchro devices to rod drive

Andicators.

Review of electronics from 20 to 25.

Examination on waterial covered from 20 to 25.

Theory of eparation, construction, efficiency.

20

HOURS AND

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HOURS. AND

supsect Score Ive

29 Transformar Instrument transformers, power and in

Applications distribution trecaforsere, autotrans~

formera.

30. Transformer Single and three phase hookups polarity, tn

Connections polyphase vincings.

31 Low voltage Short cirruits, overourrents, fuses, at

Erotective and switches circuit breakers, distrivetion

Switching Equip- systems.

nent

22 Review of EE Review of atl material covered from 1 to 31. 1.

33 Brantcation IV Examination in material covered from 1 te 31, 2 8

34 Fundamental Con- Outline of course; synbols and English aL

Sebo of Mecha- system of units; force, work, enevey, pover,

sical Engineering efficiency, and torque, Phy

of Liquids ?and gases.

ical properties

35. Preseure Fressure; definition, absotute, iL

Pheric, vacuum end concept of pi

26 Pressure Pressure measuring devices; open manometer, 1 1,

Measurement differentis! manoneter, baronster, Bourdon

sage.

37 Musa Plow Description and calculation of flow, an

Freasure, velocity, bead,

28 Bernoulli's Fressure, velocity, and flow measuring iL

Equation Gevicen,? Bernoulli's equation. Pap!

and friction heads

39 Application of Application of Bernoullt's equation to it

Bernoulli's solve practical problems by students in

Equation, ola

40 Fiutd friction ie pipes; Laminer flow; in

Friction Losses Reynold'a nunber. ?Friction ieoses on

valves and fittings

wl Evaluation of Determination of pump horsepower required iL

Punp Work for various piping eystens. Practical

pretl ens.

42 Fangs Clavstfication of pumps by types and it

ftoups. Head and flow relations in

Pumps.

---Page Break---

HOURS. AND

supsecr Score, PE

ee score ye

43. Review Review of materisl covered in 34 to 42. le

46 Examination T All material covered in periods 34 to 42. Le

45° Temperature Review temperature heat relationship; iL

Measurenents and Centigrade, Fahrenheit, Kelvin temperature

Effects of Heat scales and convarsion, Nature of heat.
Linear, differential area and volume expan+
Sion and contraction of Liquids and solide.

46 eat Measurement Definitions; British thermal unit, thermsl 1 L,
capacity, spscific heat. Application of
fundamental heat equation,

47 Meat Tracsfer- Meat transfer by conduction. Principle iL

Conduction of conduction and the influencing factors.
Practical problems,

48 Convection Heat transfer by forced and natural con- AL
vection and influencing factors,

49° Radiation Heat transfer by radistion and influencing 11.
factors,

50 Thermcdynamice The mechandeal equivalent of heat. Th ae

laws of thermodynanics. Thermodynamics

systems. Introduction to general energy

equation.

SL General Energy Generel energy equation; potential and an

Equation kinetic energy, tracaferred heat, external

work. Application of the equation.

S2 Examination 11 All material covered in pertode 48 to SL. Le

53. Feedvater Claseitication of heat exchangers, purposes, LL.

Equipaent Eypes and construction of deasrators and

evaporators

54 Avarsery Purpo. ration and construction of valves; 1 L

Fqatpaant ee, globe, check, safety, characteristice

Of piping and fiteines

'3. Nuclear Fower General requireneats and features of water 11

uipment, cooled nuclear reactors. Punpi

Piping and heat exchangers,

valv

58 corrosion and Definition, types, caues and prevention. le

Course Review Speciite application in reactors, Review

of entire course,

---Page Break---

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39

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ECT

Examination 121

Introduction

Measuring Reais

tance snd Pover

in DC cireuits,

Dic, Cirevtes

Single Phas

AC circuits

Power ia A.C.

circuses

Rectification

Transformere

Incrodsction to

ME Laboretory,

Fluid Flow

Charactertatie

Pump Curves

OURS AND

S0OFE,

ALL material covered in ME cours

Identification, safe handling, connections
of equipzent ad icstroments, Measurement
Of resistance and power using voltmeter
ameter, vheatatone bridge, chmster,
Battneter

a

Series and parallel Do circuits, verifi-
ation of Kirchoff's current and voltage
lawe, Additional practice ia interpreting
and hooking up electrical circuits,

Denonstration on oscilloscope lagging and

Leading currents as inductance end capaci-
fence are varied in an RCL network.
Measurenent of effect of inductance and
capacitance independently on current

voltage relationship. Impedance measurement.

Meacurenent of pover in AC circuits using
Wattmeters, Determine power factor in AC
circuite, Dray vector relationships

Investigation of the characteristics of
dulwave and fullwave rectifiers, Couparizon
of filter networks

Read and interpret wiring Glagrans of atngie,
parallel transformer connection, Polarity
check of traneforner. Thres phase tra

Laboratory techniques; bast

Somputetions in density, specific gravity,

Pressure vacuum and fluid flow rates.

Use of mercury differential nanometer;

determination of resistance to flow in

gate and globe valve:

Nature, smportance, and ote of characteristic

curves; obtaining head vs. flow, efficiency

and horse pover curves. Comparison of pusp

ep Erifugal and rotary,

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ANNEX NUMBER 5

HEALTH PHYSICS AND CHEMISTRY

Time: 39 houre

2%

PURPOSE: To sive the students background in the principles and purpose of Health

Physics and Water Chemistry; a vorking krowledge of personnel protection,

monitoring equipment, bi

ic chemistry, feedvater treatment and related

asalyais, and general procedures followed in research reactors,

HOURS AND

supsect SCoPE, TPE

eet sco ee

1 Introduction introduction to ib

health physica; early discovery and expe-

rience vith radiation; development of

heaith physica; comparison end application

to nuclear field,

2 ronteing Review of atomic structure and composition; 11

Radiation

3) Radiation units 7

4 Radiation unite

1

5 Biology

6 Biological

Befects

7 Ysxtmum (externel)

Fertanible

Concentrations

8 MPG. (external)

5 mre

Internal,

origin of radiation ealasion; interaction of

particles with matter; effects of tonteation

from various types of ?radiation.

Radioactive dacay-physicl and biological

Gefinitions of roentgen, curie, rep, rad,

rem, and R-BLE,

caries, rep, 4

nonographe

Characteristics of Living cells,

Eissues, organs, organ eystene; components

of cells-(gense snd chromosonss)= principal

organs of interest ir hunans,

Physical, chemical, biological and physiolo-
gical effects of radiation; acute ard chronic
exposures; external and internal hazards;
radio-sensitivity of body organs,

?Limits for external radiation exposure;
Limiting exposcre by time, distance and
shielding,

Celeulation of working tines in external
radiation fields with and vithout shielding.

Limits for internal radiation hazards,
critical orgsaa; air and water activity
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Examination I

activity,

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Activity

Analyste 1

Radistion Hazarés

and Control ie

Reactore

Fersonnel Moat-

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In-Plant Mont-

toring and

Control

Externe: Plant

Controle

Responsibilities

of Individuals to

Nuclear Plants

Relative to HP

Beaninaticn IT

Baste C4

Fostvater Trest-

mene and Antlyais

Material Balance

Eeanteation 117

Score,

Txamication of Lensoas 1 to 8

Sampling procedures; air, water, sampling
Preparations; counting techniques.

Activity deterainations, counting atatieties
(interpretetion of),

Sources of radiation hazards; concept of
control-delineation of areas; radiation
work permit; personnel and equipment
decontamination,

jetrenscts for {tlm badges and pocket
dosimeters, survey ané personnel monitoring
equipment; protective clothing-use and
avatiebility. Responsibitity for use of
this equipment.

Control of radiation arsas; monitoring of areas and effluents; area Tediation monitoring systens; control of sources and radioactive materials,

Concepts of environmental sonitorings radioactive vaste storage an disposal; ahipuont of rediouctive materials defini~ tion of acctdants and incidents, general procedures

Responsibilities of Health Phyaictst, super~ visors, snd individuals; the Health Physicist in the chain ef comand; reports and records.

Examination of Lessons 1 to 17.

Principles, theory, tenteation, acide and

Water and its inpurities, aeration, coagula tion, filtration, demineralization; PH, conductivity.

Theory of material balance and problens.

Feadwater tresteent, chantatry, material

Balance

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Area Survey,

Teedvater

Treatzent,

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OURS AND

Score, Tyre

of operation of detectors and ome

survey instruments used for alpha, beta,

Gama and neutron detection; point and

area surveys. Calibration of instruments,

Construction of calibration curves,

Use of previously caltbrated instruments ome

£0 survey a radiation area. Setting up

of access controls and determination of

working times at specified locations fa

the area,

Demonstration and practical exercise on 4 re

water aeration, handouts, coagulation,

filtration, denineralization, pl, conducti-

vity, Cl, $03 and 02 analysis,

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ANE NUMBER 6

PLANT INFORMATION

Tine; 21 houre

PURPOSE: To faniliarize students with the design and function of the aysten,

components, general hardvare and safety of nuclear plants a8 grocnd

work in preparing the student for Plant Operations Fraining. ?It ts

intended that thie course vill show the students how the theory he

bas learned in other academic subjects ties ic with actual plant

?HOURS. AND

sussecr Score, TPE

et com vee

Instrumentation General description of prinary inatrumen- aL

Eation, nuclear instrumentation, and where

located, method of control by control rod

drives, ?and primary system temperature

Primary System systen and conponents used to seature an

Instrumentation temperature, flow and level.

Nuclear Iostru- Problems encountered in detaction, types iL

entation of detectors, and the source range, power

range chanceli

Control Rod Drive Functions, design considerations, cous- Lt

Syaten, Eruction of control rod drive mechentans;

Eogether witk the sources of power, inter=

locks and associated instrumentation,

Reactor Protective Ways of controlling a reactor during operas 2 L

Syatens fon, design requirements of « control rod

eystem, types of control rods (shin and

ety), conditions which could cause damage

Goss of coolant, loss of flow and reactivity

adateson)

Gperaicnal Aspects Sampling of primary and secondary water, what 1 L

of Water Chemistry is anelyzed for, vhat te expected or require

Limite and what corrective action is used.

Methods of chenical addition blowdown, various

methods of water chemistry control.

Shielding Discussion of primary and secondary shielding 11

construction, materiale, shadow shielding

using plant Components and shield water

cooling system.

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8

?HOURS AND

SUBJECT Score rd

8 Refueling Discussion of general refueling proce- iL

dures, tools and precautions

9 Examination Examination of material covered from to 8. 12

10 Reactor Safety AEC regulations and organization Mnslysie 1

Requirements of hazarés evaluation and what may be found

therein,

11 Core Design Discussion of what data is avatlable from tL

Reports and core design reports from contractors and «

History of diecus

Muckeer Inet Aneidents

dents personnel.

12° Tour of EXC Tour of the FRNC viming pool reactor to ome

Reactors point out inportent syaten components.

13° PaNC Tour Detailed tour of the FRNC swimming poot ame

reactor potating out detaile of systens

and {netrumentation,

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