

Fundamentals of Particle Accelerators

U.S. Particle Accelerator School
Old Dominion University, Winter 2018

Mike Syphers, Northern Illinois University/Fermilab

Elvin Harms, Fermilab

Kent Wootton, SLAC National Accelerator Laboratory

Karie Badgley, Fermilab

David Tarazona, MSU

Class Overview

- Students:

- ~24 in the class

- ~14 from labs/research centers

- ~10 from universities (some are also at labs)

- Various stages/levels of education:

- 3 PhD, 5 MS, 6 gs, 7 BS, 3 ug/as

- credit (undergraduate) vs. audit

- ~11 – Credit ~11 – Audit ~2 – Special Non-credit

- PLEASE CONFIRM -- initial the sheet!

Professional Background

• About the Instructors

• MJS

• EH

• KW

• KB

• DT

• About the Students...

Course Overview

- scope and goals of course
- lectures, labs (H/W & Computer), homework, exam
 - lab & study room open in evening
 - homework assignments due 9:00 a.m. !!
- physics vs. technology
- cyclic vs. linear vs. ...
- lots to cover in SHORT time !!

General Course Progression...

- General Physics, Relationships, Definitions
- Particle Beam Transport and Acceleration
- Repetitive Systems and Particle Storage
- Effects of errors, high intensity
- Synchrotron Radiation and Emittance Control
- Design Considerations (throughout)
- Facilities: Present and Future (throughout)

Syllabus

This
progression
could certainly
evolve during
the school...

Course Syllabus – 2018 January 15-26

Wk 1 <i>Day</i>	9:00 - 9:50	10:00 - 10:50	11:00 - 11:50	14:00 - 14:50 15:15 - 16:45	>19:00
Mon	Introduction & Prerequisites	Accelerators & Particle Beams	Steering & Focusing	Accelerator Components LAB Intro	<i>LAB/Study</i>
Tues	Transverse Motion	Phase Space Distributions	Courant-Snyder Parameterization	Lab/Study Session	<i>LAB/Study</i>
Wed	Accelerating Structures	Longitudinal Focusing	Transverse Effects and Dispersion	Lab/Study Session	<i>LAB/Study</i>
Thu	Motion through Periodic Systems	Repetitive Systems: Transverse Stability	Repetitive Systems: Acceleration	Lab/Study Session	<i>LAB/Study</i>
Fri	Collection of Beam Optics Modules	Longitudinal Manipulations	A synchrotron and a Linac	Lab/Study	

Wk 2 <i>Day</i>	9:00 - 9:50	10:00 - 10:50	11:00 - 11:50	14:00 - 16:45	>19:00
Mon	Linear Errors & Adjustments - I	Linear Errors & Adjustments - II	Nonlinear Motion and Resonances	Lab/Study Session	<i>LAB/Study</i>
Tues	Synchrotron Radiation	Storage Ring Light Sources	X-Ray Free Electron Lasers	Lab/Study Session	<i>LAB/Study</i>
Wed	Emittance Dilution	Intro to Intensity Dependent Effects	Beam Instrumentation and Diagnostics	Lab/Study Session	<i>LAB/Study</i>
Thu	Overview of an Accelerator Facility	***** Spare Topic *****	Outlook for the Accelerator Field	Review (13:00-13:50)	<i>LAB/Study</i>
				Finish Labs	
Fri	Final Exam (9:30 a.m.)				

Course Web Site

👁 Daily updates to material, syllabus, notifications, etc., will be maintained on the course web site:

👁 <http://nicadd.niu.edu/~syphers/uspas/2018w>

The screenshot shows a web browser window with the URL <http://nicadd.niu.edu/~syphers/uspas/2018w/index.html#winter-2018-uspas-session>. The browser's address bar and tabs are visible at the top. The website content is organized into two main columns. The left column contains a 'Course Syllabus' section with a list of topics and dates, including '1 Mon: Introductions', '2 Tue: Transverse Motion', '3 Wed: Longitudinal Motion', '4 Thu: Motion through Periodic Systems', '5 Fri: Beam Manipulations', '6 Mon: Errors and Adjustments', '7 Tue: Synchrotron Radiation', '8 Wed: Challenging Liouville', '9 Thu: Wrapping Up', and '10 Fri: Final Exam'. Below the syllabus is a section for 'Laboratory Sessions'. The right column features the title 'Winter 2018 USPAS Session' in large, bold letters. Below the title, it states 'U.S. Particle Accelerator School, Hosted by Old Dominion University.' and 'Held 15-26 January 2018, in Hampton, VA.' A 'Team:' section lists five members: Mike Syphers, Evin Harms, Kent Wootton, Karie Badgley, and David Tarazona. A 'Purpose and Audience' section describes the course's goal to introduce students to particle beam accelerators. A 'Prerequisites' section mentions that credit-seeking students should have completed courses in special relativity.

Winter 2018 USPAS Session

Course Syllabus

1 Mon: Introductions

- 1.1 Getting Started
- 1.2 Review of Course Prerequisites
- 1.3 Accelerators and Beams
- 1.4 Steering and Focusing Charged ...

2 Tue: Transverse Motion

3 Wed: Longitudinal Motion

4 Thu: Motion through Periodic Systems

5 Fri: Beam Manipulations

6 Mon: Errors and Adjustments

7 Tue: Synchrotron Radiation

8 Wed: Challenging Liouville

9 Thu: Wrapping Up

10 Fri: Final Exam

Laboratory Sessions

Winter 2018 USPAS Session

U.S. Particle Accelerator School, Hosted by Old Dominion University.

Held 15-26 January 2018, in Hampton, VA.

Team:

- Mike Syphers, Northern Illinois University and Fermilab
- Evin Harms, Fermi National Accelerator Laboratory
- Kent Wootton, SLAC National Accelerator Laboratory
- Karie Badgley, Fermi National Accelerator Laboratory
- David Tarazona, Michigan State University

Purpose and Audience

The purpose of this course is to introduce the students to the physics and technology of particle beam accelerators. This course is suitable for last year undergraduate students or students from other fields considering accelerator physics as a possible career. This course also can provide a broader background to engineers and technicians working in the field of accelerator technology.

Prerequisites

Credit-seeking students: Courses in special relativity (at level of French, "Special Relativity," or Resnick,

Homework/Labs

- Problems: see the handout/web site - ~3-4 each day
 - Homework problems due 9:00 a.m. next morning
- Afternoon Lab sessions
 - Will divide into 8 groups of ~3-4 people each
 - 4 hardware labs; 4 computer "labs"
 - Labs can be done in ~2-hr slot; room also will be available at night...

Labs

USPAS - Fundamentals					
Winter 2018 Lab Schedule					
Week #1					
	Monday	Tuesday	Wednesday	Thursday	Friday
Dipole hands-on		Team Roentgen	Team Edwards	Team Kerst	Team Veksler & MacMillan
Dipole simulation (computer)	Intro and Demonstrations	Team Wideroe	Team Roentgen	Team Edwards	Team Kerst
RF hands-on		Team Lawrence & Livingston	Team Wideroe	Team Roentgen	Team Edwards
Longitudinal Dynamics (computer)		Team Cockroft & Walton	Team Lawrence & Livingston	Team Wideroe	Team Roentgen
BPM & Toroid		Team Christofilos, Courant & Snyder	Team Cockroft & Walton	Team Lawrence & Livingston	Team Wideroe
Emittance Issues (computer)		Team Veksler & MacMillan	Team Christofilos, Courant & Snyder	Team Cockroft & Walton	Team Lawrence & Livingston
Quadrupole hands-on		Team Kerst	Team Veksler & MacMillan	Team Christofilos, Courant & Snyder	Team Cockroft & Walton
Transverse Dynamics (computer)		Team Edwards	Team Kerst	Team Veksler & MacMillan	Team Christofilos, Courant & Snyder
Week #2					
	Monday	Tuesday	Wednesday	Thursday	Friday
Dipole hands-on	Team Christofilos, Courant & Snyder	Team Cockroft & Walton	Team Lawrence & Livingston	Team Wideroe	
Dipole simulation (computer)	Team Veksler & MacMillan	Team Christofilos, Courant & Snyder	Team Cockroft & Walton	Team Lawrence & Livingston	
RF hands-on	Team Kerst	Team Veksler & MacMillan	Team Christofilos, Courant & Snyder	Team Cockroft & Walton	
Longitudinal Dynamics (computer)	Team Edwards	Team Kerst	Team Veksler & MacMillan	Team Christofilos, Courant & Snyder	
BPM & Toroid	Team Roentgen	Team Edwards	Team Kerst	Team Veksler & MacMillan	
Emittance Issues (computer)	Team Wideroe	Team Roentgen	Team Edwards	Team Kerst	
Quadrupole hands-on	Team Lawrence & Livingston	Team Wideroe	Team Roentgen	Team Edwards	
Transverse Dynamics (computer)	Team Cockroft & Walton	Team Lawrence & Livingston	Team Wideroe	Team Roentgen	

Might also
evolve...

...will discuss further in
afternoon session today

Some Philosophy

- Encourage discussion and interaction; not just going through a collection of slides; will do a lot on the white boards
- Much of what is covered is in the textbook; hope that most important concepts will be delivered during class
- Apologies
 - Note: Order of material is different than in textbook; see web site ("Suggested Reading") for cross-reference
 - our experience has been FNAL, SSCL, BNL, NSCL, FRIB, SLAC, Australian Synchrotron -- many examples are from these labs; will attempt to be general...
- What are your expectations?

Today...

☉ Morning

- ☉ Introduction to Course; Physics Review
- ☉ Overview of Accelerators
- ☉ Particle Beam Transport and Focusing

☉ Afternoon

- ☉ Electrostatic and magnetic components
- ☉ Introduction to the lab and computer studies
- ☉ Homework No. 1 is due Tomorrow at 9:00 a.m.