

## **SAINTS Short Course: *Introduction to Accelerator Physics (SC-Accp)***

**17 – 19 July 2023**

### **Facilitators:**

- [JM] Dr Joele Mira, PhD (Stellenbosch University), iThemba LABS NRF
- [MS] Dr Muneer Sakildien, PhD (University of Jyväskylä), iThemba LABS NRF
- [SS] Dr Skye Segal, PhD (University of Cape Town), iThemba LABS NRF
- [HB] Mr Hugo Barnard, MSc (Ghent University), iThemba LABS NRF

An **ONLINE** short-course on Introduction to Accelerator Physics offered over three days on specialized topics tailored to suit post-graduate students (Honors – PhD), and junior research staff working on projects involving accelerators. A total of six lecture sessions will be offered in three days, with each session lasting three hours.

**Course Co-ordinator:** Hugo Barnard (e-mail: [hbarnard@tlabs.ac.za](mailto:hbarnard@tlabs.ac.za))

**Target group:** Honors/masters/doctoral students, junior research staff working on projects involving accelerators

**No. of lectures/contact sessions:** 6 (3 hours each)

**Course certificate to be issued:**

- Attendance (provided attendance > 90 %)

**Presentation venue:** virtual (Zoom platform: *Link to be sent to registered participants*)

**Course dates/times:** 17 – 19 July, with a morning session (09h00 to 12h00) and an afternoon session (13h30 to 16h30)

**Course registration deadline:** 15 July 2023

**Course registration link:** <https://indico.tlabs.ac.za/event/123/registrations/91/>

**Contact for queries on course:** Course Co-ordinator: [hbarnard@tlabs.ac.za](mailto:hbarnard@tlabs.ac.za)

**Contact for general queries:** SAINTS Co-ordinator, e-mail address: [saintsadmin@tlabs.ac.za](mailto:saintsadmin@tlabs.ac.za)

### **Course Outline:**

Six lecture sessions on specialized accelerator physics topics, 3-hours per lecture session

- **Session 1: Ion Sources [SS]: 17 July 09h00 – 12h00**

Definition of an ion; definition of an ion source; Different particles types that can be produced with an ion source; Fundamental concepts such as beam intensity; Classification of ion sources; Ion Source used for Radionuclide Production and Radiobiology; Thermionic emission; Electron impact ionization; Collisions; Gyromotion in an ion source; Ion Sources used for Subatomic Physics research



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- **Session 2 Accelerators [MS] 17 July 13h30 – 16h30**

Types of linear accelerators; Van der Graaff; The Tandetron; Types of circular accelerators; The resonance principle in a cyclotron; Magnetic focusing; Electric focusing; The phase relations during acceleration; Deflector

- **Session 3: RF systems [HB] 18 July 09h00 – 12h00**

The RF resonators at iThemba LABS; Analogue components; Circuits; Transients; AC theory – Phasors, Impedance; Parallel resonant circuits; Series resonant circuits; Power; Q-factor; Capacitance and inductance of co-axial cables; Telegraph equations; Sine waves along a transmission line; Reflection at the load; Impedance of a load and a section of transmission line; Transmission lines as part of the RF oscillator

- **Session 4: Beam Optics [JM] 18 July 13h30 – 16h30**

Introduction to beam emittance and Liouville's theorem; Weak Focusing; Solenoid lens principle and derivation of equation of the focal point; Einzel lens principle and derivation of equation of focal point; Strong Focusing; Focusing principles of Electrostatic and Magnetic quadrupole lenses; Derivation of the magnetic field line equations; Derivation of the matrix equations for a first approximation to the focusing of quads; Derivation of the first order approximation for a drift space; Dipole Magnets; Principles of the dipole magnet; Derivation of the magnetic rigidity equation using energy relations equations

- **Session 5: Magnets [HB] 19 July 09h00 – 12h00**

Introduction: History, Definition of terms, Units; Maxwell's equations; Field lines; DC electromagnets – layout, yoke shapes; Dipole magnets, Quadrupole magnets; Materials, BH curves; Fringe fields and shims; Force on coils and yoke; Force on particles; Rigidity; Bending radius; Strength of B in magnet; Effective length; Beam uniformity; Measuring devices: rotating coil, hall probe, NMR; Designing a magnet analytically; FEA design

- **Session 6: Beam Diagnostics [JM] 19 July 13h30 – 16h30**

Introduction – what are diagnostics; Types; Overview of the implementation at iThemba LABS; Time structure of a bunched beam; Diagnostics for Intensity; Diagnostics for Transverse properties; Diagnostics for Emittance; Diagnostics for Longitudinal parameters; Diagnostics for Beam energy



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