FMRI core syllabus

How to learn from videos: https://www.youtube.com/watch?v=d7IPiNE4_QE

Tom Liu's lectures: https://www.youtube.com/channel/UCWUn9KXLEFqfUeTY0tmC5nQ
FSL course lectures: https://www.youtube.com/playlist?list=PLvgasosJnUVl_bt8VbERUyCLU93OG31h_
Coursera: Principles of fMRI 1: https://www.coursera.org/learn/functional-mri
Coursera: Principles of fMRI 2: https://www.coursera.org/learn/functional-mri-2

Joseph Devlin - Designing and Analysing fMRI Experiments:
https://ucl.podia.com/designing-and-analysing-fmri-experiments

https://people.bss.phy.cam.ac.uk/~rea1/Nov15_2016_Talk/Magical_Magnetic_Resonance_Imaging.pdf

Mathematics

(See David Dorran, TU Dublin https://www.youtube.com/user/ddorran/featured?app=desktop)

Linear algebra (vectors and matrices) https://www.youtube.com/watch?v=fNk_zzaMoSs&list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab

Complex numbers
Waves: amplitudes, frequency and phase
Basic calculus
Harmonic analysis:
   The Fourier transform and Fourier analysis (conjugate variables)
    Continuous vs discrete functions
    Hilbert transform
    AM and FM
    Sampling and the Nyquist criterion
    Aliasing
    Convolution and deconvolution

Interpolation
Intro to systems analysis: Linear vs non-linear systems

Statistics

The normal distribution and averages
Hypothesis tests
Parametric vs non-parametric statistics
Significance
The t statistic
The F statistic
Least squares estimate (ordinary and weighted LS)
GLM
Linearity
Correlation (and autocorrelation)
Multiple comparisons, FDR and false positives
CRLB?
Bayes theorem and inference?

Multiple comparisons
Within subjects
Between subjects

Psychology

Inference, reverse inference
Reinforcement learning

Physics

Introduction to electricity and magnetism: fields, current in a wire, Maxwell's equations?

Introduction to NMR: spin, magnetization, origins of the signal, spin density, the Bloch equations

   Is quantum mechanics necessary for understanding magnetic resonance?
https://onlinelibrary.wiley.com/doi/abs/10.1002/cmr.a.20123

Introduction to Relaxation: relaxation by a random field, T1, T2, B0 and relaxation rates
Inversion, saturation
Echoes (spin, gradient; include the effects of diffusion)
Isotropic diffusion and the PGSE sequence
Chemical shift and the NMR spectrum

Intro to pulse sequences

Introduction to image formation
K-space
Spatial selection

Intro to anatomical scans

Magnetism: diamagnetism, paramagnetism, superparamagnetism, ferromagnetism
Magnetic susceptibility: water, tissue, blood, bone, non-biological materials
(including contrast agents)
Flow sensitivity in NMR and MRI

EPI and EPI artifacts
Acceleration (in-plane, slice)

Engineering

Introduction to scanner architecture
Electromagnet basics
Introduction to scan suite layout
Scanner hardware control and pulse sequences

Gradient coils
Transmission RF coils
Receive RF coils

Biology

Introduction to cell biology: cell structure and functions
Brain cell types
Introduction to neuronal signaling: neurons, synapses, the resting potential,
neurotransmitters,
Introduction to cellular metabolism: glucose, lactate, TCA cycle, etc.

Sympathetic and parasympathetic nervous systems
Intro neuroanatomy: terminology, gray matter, white matter, Brodman regions,
connectivity,

Intro vascular anatomy
Blood supply basics (MABP, CPP, systolic, diastolic)
https://www.youtube.com/watch?v=K4QexcCqcCU
Blood flow control: Blood flow, perfusion, the CBV, ATT, vasomotion, autoregulation, CVR,

Introduction to respiratory physiology https://www.youtube.com/watch?v=7qTJo3zRjrY
https://www.youtube.com/watch?v=8t-xIsncnIs
 https://www.youtube.com/watch?v=HIvM2rdHWzI
https://www.youtube.com/watch?v=-mL_NQ3pKnA
https://medschool.cuanschutz.edu/docs/librariesprovider60/default-document-library/oxygenation-and-oxygen-therapy.pdf?sfvrsn=4ca831b9_2

Introduction to cerebral metabolism: respiration, blood supply, oxygen and glucose utilization
Neurovascular coupling

https://catalogs.northwestern.edu/tgs/courses-az/bmd_eng/

Image processing and analysis

Introduction to command line computing, scripting, directory structure, links, permissions, etc. (See Andy's Brain Book)
Introduction to data formats, data structure, bits, headers,

Registration
Volume realignment
Slice timing correction
Smoothing

Introduction to machine learning: classifiers, supervised vs unsupervised learning
    Intro to neural nets
    Generative adversarial networks: https://www.youtube.com/watch?v=8L11aMN5KY8

Independent component analysis
Principal component analysis
ROC analysis
The hemodynamic response function

http://practical-neuroimaging.github.io/. See BMD_ENG 301-0 Quantitative

Systems Physiology and BMD_ENG 302-0 Quantitative Systems Physiology

https://andysbrainbook.readthedocs.io/en/latest/

https://www.youtube.com/c/mumfordbrainstats

Experimental design

Block designs
ER-fMRI

Bioohysics

Oxy- and deoxyhemoglobin properties
Intro to pulse oximetry: https://www.youtube.com/watch?v=LQdiKbaB7ro https://www.youtube.com/watch?v=CA_5Yn1WW0M

The BOLD dilution model and OEF

Draining vein effects (magnetic susceptibility model)
Inflow and apparent T1
Motion in fMRI
Physiological effects in fMRI

Practical issues

Safety: stray field effects,
Workflow: checklists
Basic scanner operation
Anatomical scanning
Functional scanning