1) Derive maximum height of projectile launched at angle θ and initial speed v_0.

- Use equation for Δv^2 in terms of g and y.

2) Derive trajectory of projectile (i.e. $y(x)$)

- solve for t from x equation
- plug t into y equation and simplify

3) Derive range of projectile launched at angle θ and initial speed v_0 (assume the final height is the same as the initial height).

- Use projectile motion trajectory equation to solve for change in x

4) Derive a formula relating Δv^2 to an object's acceleration a and change in position Δx (1D).

- Use work-energy theorem to derive this

5) Work out the units of the gravitational constant G (MKS).

- Use Newton's law of gravity to deduce the units

6) Write down Maxwell's equations for electrostatics and magnetostatics (separately).

- Consider changes of electric and magnetic fluxes or charge/current distributions behaviors with time.

7) Derive Poisson's equation and Laplace's equation from the electrostatic Maxwell equations.

- Substitute the definition of the electrostatic potential into Maxwell's equations for Poisson's equation
- Assume that $\rho = 0$ for Laplace's equation

8) Derive the electric field from an infinite plane with surface charge density σ.

- Use Gauss's law with a thin pillbox with one face outside and another inside the plane (faces are of area A)

9) Derive the electric field from a line charge with linear density λ.

- Use Gauss's law with a cylinder of radius s and length ℓ (the length cancels)

10) Derive the force for a magnetic field on a small piece of current carrying wire.

- Consider the small charge element from the current

11) Derive the vector potential definition as a consequence of the Maxwell Equation $\vec{\boldsymbol{\nabla}} \cdot \vec{\boldsymbol{B}} = 0$

12) Derive the magnetic field for an (1) infinite straight wire, (2) a solenoid, and (3) a toroid

- Use the appropriate paths to integrate using $\int \vec{\boldsymbol{B}} \cdot \mathrm{d}\vec{\boldsymbol{l}} = \mu_0 I_{\mathrm{enc}}$
- For the toroid let the infinite wire coil onto itself N times

13) Derive the radius and frequency of cyclotron motion (circular motion of charged particle in magnetic field)

- Use the Lorentz force law for a charge in a magnetic field and centripetal acceleration formula for the radius
- then use velocity-angular frequency relation to find the angular frequency

14) Derive the characteristic times for (1) RL and (2) RC circuits and (3) the resonant frequency of an LC circuit.