5.1: Introduction

This chapter deals with the calculation of gravitational fields and potentials in the vicinity of various shapes and sizes of massive bodies. The reader who has studied electrostatics will recognize that this is all just a repeat of what he or she already knows. After all, the force of repulsion between two electric charges q_1 and q_2 a distance r apart *in vacuo* is

$$\frac{q_1 q_2}{4\pi\varepsilon_0 r^2}, \tag{5.1.1}$$

where ε_0 is the permittivity of free space, and the attractive force between two masses M_1 and M_2 a distance r apart is

$$\frac{GM_1 M_2}{r^2}, \tag{5.1.2}$$

where G is the gravitational constant, or, phrased another way, the *repulsive* force is

$$-\frac{GM_1 M_2}{r^2}. \tag{5.1.3}$$

Thus all the Equations for the fields and potentials in gravitational problems are the same as the corresponding Equations in electrostatics problems, provided that the charges are replaced by masses and $4\pi\varepsilon_0$ is replaced by $-1/G$.

I can, however, think of two differences. In the electrostatics case, we have the possibility of both positive and negative charges. As far as I know, only positive masses exist. This means, among other things, that we do not have "gravitational dipoles" and all the phenomena associated with polarization that we have in electrostatics.

The second difference is this. If a particle of mass m and charge q is placed in an electric field $\mathbf{E}$, it will experience a force $q\mathbf{E}$, and it will accelerate at a rate and in a direction given by $q\mathbf{E}/m$. If the same particle is placed in a gravitational field $\mathbf{g}$, it will experience a force $m\mathbf{g}$ and an acceleration $m\mathbf{g}/m = \mathbf{g}$, irrespective of its mass or of its charge. All masses and all charges in the same gravitational field accelerate at the same rate. This is not so in the case of an electric field.

I have some sympathy for the idea of introducing a "rationalized" gravitational constant Γ, given by $\Gamma = 1/(4\pi G)$, in which case the gravitational formulas would look even more like the SI (rationalized MKSA) electrostatics formulas, with 4π appearing in problems with spherical symmetry, 2π in problems with cylindrical symmetry, and no π in problems involving uniform fields. This is unlikely to happen, so I do not pursue the idea further here.