10. (a) Use Faraday's law to determine the *e.m.f.* induced around a coil of N turns of cross-sectional area A rotating at an angular velocity ω about an axis in the plane of the coil and normal to a uniform magnetic field B. [5]

(b) The headlight of a bicycle is powered by a small generator (dynamo) that is driven by the wheel of a bicycle. The generator is driven by means of a friction wheel, such that a point on the circumference of the friction wheel moves at the same speed as the linear speed of the bicycle. The generator contains two coils connected in series with appropriate polarity, as shown in Figure 5.

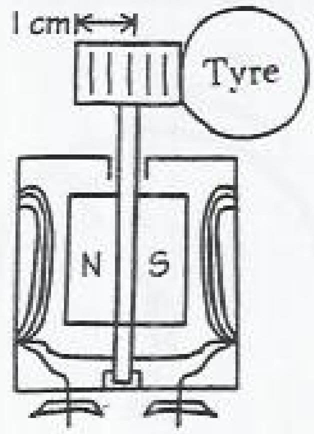

Figure 5

Each coil consists of 70 turns and has an area of 800 mm^2. A small permanent magnet is rotated in front of the coils, so that the magnitude of the magnetic field varies between 0.1 T and zero. If the speed of the bicycle is 5.7 ms^{-1} and the radius of the friction wheel is 10 mm, what will be the angular frequency of the friction wheel? What will be the maximum *e.m.f.*? If the resistance of each coil is 2 Ω, what is the power of the dynamo? [6]

(c) A bicycle wheel of radius R = 330 mm rotates at an angular speed ω = 38 s^{-1} in a plane perpendicular to a constant magnetic field of magnitude 0.14 T. Use Faraday's law to calculate the *e.m.f.* generated between the centre of the wheel and its rim. [5]

(d) Use the Lorentz force to calculate the *e.m.f.* generated between the centre of the wheel and its rim for the same system as described in problem (c). [4]