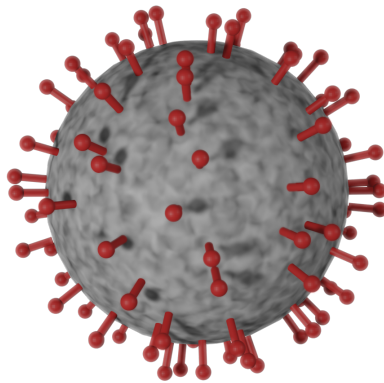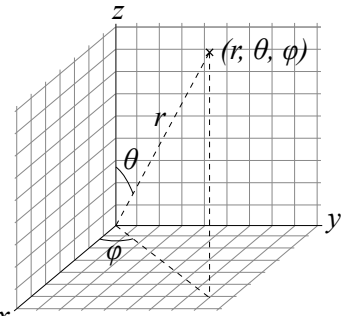## 4 Introduction to Graphics (rkm38)

Your task is to create a simple visualization of SARS-CoV-2 using only two primitives:

- a sphere of radius 1, and

- a cylinder of a height 2, its base of radius 1, and the main axis aligned with OZ,

both centred at the origin. An example of such a visualization is shown in Fig. 1 below.

(Fig. 1)   (Fig. 2) x

(*a*) Draw a scene graph for the SARS-CoV-2 model, shown in Fig. 1, in which the main shape is a sphere and each spike consists of a cylinder and a sphere. Use the hierarchy of the primitives (sphere — cylinder — sphere) so that the entire object can be animated by transforming the main shape.   [4 marks]

(*b*) Provide transformation matrices for each node of the graph. You do not need to provide the results of the matrix multiplication. Assume that you have a list of N spherical coordinates (ϕ_k, θ_k), for $k = 1, \ldots, N$, which indicate the positions of the spikes. Use the coordinates as shown in Fig. 2. The main body has a radius of 1, the cylinder of the spike has a length of 0.1, a radius of 0.025 and the sphere of the spike has a radius of 0.05 with the centre at the base of the cylinder.   [10 marks]

(*c*) How can you randomly generate the spherical coordinates (ϕ_k, θ_k) of the spikes so that they are (a) evenly distributed over the sphere and (b) not clustered together (two or more spikes are not too close to each other)? Write pseudocode for generating (ϕ_k, θ_k).   [6 marks]