PART III

This part carries 32 per cent of the total examination marks.

You should attempt **TWO** *questions from this part, either Question 17 or Question 18* **and** *either Question 19 or Question 20. Questions are equally weighted, but note that about one-third of the marks for each question are awarded for good problem-solving technique, with Preparation, Working and Checking stages.*

Each *question in this part* **must** *be answered in a separate single-question answer book.*

EITHER **Question 17**

It is recommended that when picking up a heavy object one should bend at the knees rather than from the waist. The latter situation can be modelled by treating the spine as a rod, pivoted about its base (Figure 8) and such that the weight of the upper body acts through the centre of mass of the rod. The back is then supported by a muscle attached to the spine at the shoulder and making an angle of 12° with it. Assuming the mass of the lifter's upper body to be 50 kg and his shoulder to be two-thirds of the way along his spine from its base, what is the magnitude of the total force exerted at the base of his spine when he bends over to pick up a 10 kg box? Does your answer show why this is an unsafe way to lift up a heavy object?

(For the purposes of this question, you may take the magnitude of the acceleration due to gravity as $10\,m\,s^{-2}$.)

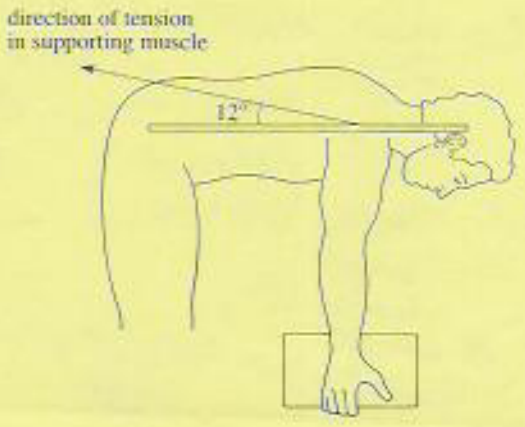

Figure 8

OR **Question 18**

A laser produces a beam of monochromatic light of frequency 9.40×10^{14} Hz that is incident normally on a large vertically ruled diffraction grating. The corresponding diffraction pattern, consisting of five bright spots arranged symmetrically in a horizontal line, is observed on a large planar screen 2.00 m away from the grating. (The screen is, of course, on the opposite side of the grating to the laser and its plane is perpendicular to the initial beam from the laser.) The central spot is 0.99 m from the closest pair of spots and 3.83 m from the other pair. The laser is then replaced by one that produces monochromatic light of frequency 1.64×10^{15} Hz. Describe the pattern of spots that now appears on the screen, specifying the number of spots observed and their spacing on the screen.

AND ... (please turn over)