Course and assignment number:

Tutor Marked Assignment

S271 01

Make sure you know how to complete and send in your TMA and PT3 form: detailed instructions are given in your student handbook (or supplement).

Covering: **Units 1–4**
Cut-off date:
Friday 26 April 1996

This assignment consists of *three* questions, which relate to the material covered in Units 1 to 4 of Block A.

Question 1

This question relates to Units 1 and 2 and carries 25% of the marks for this assignment.

This question should be answered in the problem solving format, introduced in Block A. This means that you should try to structure your answer to this question into the stages of preparation, working and checking, described in the audiotape sequences of Units 1 and 2 and in the Problem Book. The preparation stage should outline your understanding of the question, including suitable diagrams, known quantities and standard equations that might help in the solution. The working stage will probably be the bulk of your answer and will include algebra and numerical calculations. Finally, be sure to include the checking stage, by writing down some argument (based on units, limiting cases, trends etc.) that supports your answer.

The marks are allocated to the three stages as follows:

Preparation	*10 marks*
Working	*12 marks*
Checking	*3 marks*

In this question, more marks than will normally be the case are allocated to preparation and checking to emphasize the importance of the problem solving technique.

The poet Longfellow tells us that:

> Swift of foot was Hiawatha;
> He could shoot an arrow from him,
> And run forward with such fleetness
> That the arrow fell behind him!

Actually, this is not such a tough trick to pull off, provided the arrow is aimed high enough. Suppose that, when Hiawatha aims vertically, his arrow reaches a maximum height of 20 m. If the arrows are always released at the same speed, regardless of their direction, and Hiawatha can run at $7\,\mathrm{m\,s^{-1}}$, what is the minimum angle above the horizontal at which Hiawatha must aim in order to outrun the arrow? In the Preparation stage, you should state any assumptions you intend to make, and include suitable diagrams and equations.

Question 2

This question relates to Unit 4 and carries 35% of the marks for this assignment.

A uniform cylindrical flywheel of mass m' can rotate without friction about a horizontal shaft coincident with its central axis. One end of a long flexible string of negligible mass is fixed to the curved surface of the cylinder and wound round the circumference. The flywheel is initially at rest, when a load of mass m is attached to the free end of the string and allowed to fall, thus causing the flywheel to rotate.

(a) Draw a diagram showing the relevant forces acting on the flywheel and on the falling load. *(3 marks)*

(b) Use Newton's laws of translational motion to show that the *acceleration* of the falling load can be expressed by

$$a_x = g - F_t/m$$

where F_t is the magnitude of the tension in the string and the x-axis points vertically downwards. *(8 marks)*

(c) Combine the result of part (b) with the laws of rotational motion, applied to the flywheel, to show that

$$a_x = g\,\frac{m}{m + \frac{1}{2}m'}$$ *(16 marks)*

(d) Derive, in terms of m, m' and g, a general formula for the magnitude of the *tension* in the string during the fall, and calculate its value in the special case when the mass of the load is equal to the mass of the flywheel. *(8 marks)*

Question 3

This question relates to Unit 4 and carries 40% of the marks for this assignment.

Carry out the home experiment with a rolling cylinder, described in Section 2.2 of Unit 4 and write a report about it. (See below for advice on the structure of the report.)

To obtain full marks for the experimental work, you can use *any one* of the following three approaches:

1 Take at least 20 time measurements for a single distance s travelled through a fixed height h. By taking appropriate averages of your measurements, determine the value of g from Equation 16 of Unit 4. Use the simple rules given in Section 2.1 to work out the uncertainty in g.