Course and assignment number:

Tutor Marked Assignment

S271 02

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 6–9**
Cut-off date:
Friday 5 July 1996

This assignment consists of **four** *questions, which relate to the material covered in Units 6 to 9 of Block B.*

Question 1

This question relates to Unit 6 and carries 15% of the marks for this assignment.

A plastic cylinder of height $2h$ and cross-sectional area A floats in equilibrium in a fluid of density ρ in such a way that the bottom of the cylinder is a distance h below the surface of the fluid. This situation is shown in Figure 1(a), where the x-axis has been chosen to point vertically downwards.

(a) Derive an expression in terms of known quantities and g for the force F_x^{applied} that must be applied to the top of the cylinder to depress it by a distance x, as shown in Figure 1(b). *(8 marks)*

(*Note*: You will need to use Archimedes' principle, which states that the upward buoyancy force on an object in a fluid is equal in magnitude to the weight of the fluid displaced. When the cylinder is floating, the weight of the displaced fluid equals the weight of the cylinder. The force required to depress the cylinder below its equilibrium position will therefore be equal to the weight of the *additional* fluid displaced when the cylinder is depressed.)

(b) State why, when the cylinder is released, its vibrations will be simple harmonic provided the viscosity and surface tension of the fluid are ignored (leaving gravity and the buoyancy force as the only forces acting on the cylinder). Write an expression for the force constant in terms of known quantities and g. *(4 marks)*

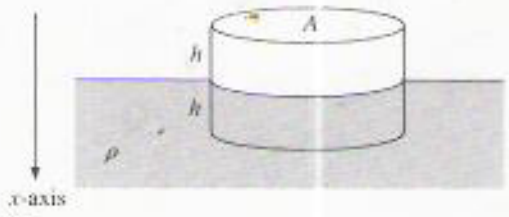
(c) What is the maximum theoretical value of x up to which the vibrations will remain simple harmonic? *Briefly* explain your reasoning. *(3 marks)*

Question 2

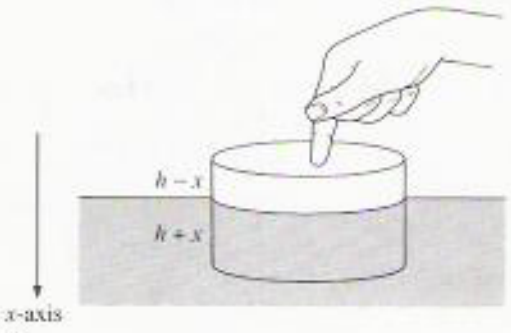
This question relates to Unit 7 and carries 20% of the marks for this assignment. Note that 8 marks are allocated to 'good problem solving techniques', along the lines described in the Problem Book and the rubric for Question 1 of TMA 01. You should be careful to draw a diagram as part of the preparation stage.

A laser (call it laser 1) produces a beam of monochromatic light of wavelength 633 nm that is incident normally on a diffraction grating whose slits are vertical. The diffraction pattern is recorded on a screen and the *second order* is seen to occur at an angle of 57.6° with respect to the incident beam. A second laser (call it laser 2) with monochromatic light of frequency 9.40×10^{14} Hz is then substituted for laser 1 and a single vertical slit is substituted for the diffraction grating (at exactly the same distance from the screen and centred so that the illumination is normal).

What width of single slit would lead to the *first minimum* of the single slit diffraction pattern coinciding in position on the screen with the *first maximum* in the diffraction pattern from the diffraction grating?



(a)



(b)

FIGURE 1 (a) The cylinder floating in equilibrium.

(b) When the cylinder is displaced downwards by x the fluid exerts an upward restoring force.