# UNIVERSITY OF DUBLIN

MA1241-1

## TRINITY COLLEGE

FACULTY OF ENGINEERING, MATHEMATICS
AND SCIENCE

SCHOOL OF MATHEMATICS

**JF Theoretical Physics**
**JF Mathematics**
**SF Two Subject Moderatorship**

**Trinity Term 2014**

MA1241 — CLASSICAL MECHANICS I

Thursday, May 15 GOLDHALL 09:30 — 11:30

Dr. S. Kovacs

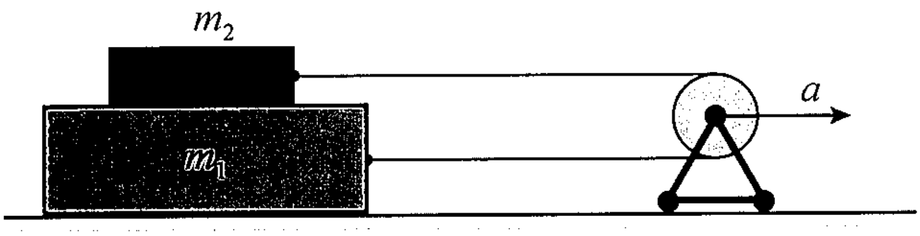
Credit will be given for the best 2 answers.

All questions have equal weight.

'Formulae & tables' are available from the invigilators, if required.

Non-programmable calculators are permitted for this examination—please indicate the make and model of your calculator on each answer book used.

1. Two blocks of mass $m_1$ and $m_2$, with $m_1 > m_2$, are pulled by a massless string passing on a massless pulley as shown in the figure. The lower block, of mass $m_1$, can slide without friction on the horizontal plane, while the friction force between the two blocks is non-zero. The pulley is given a constant acceleration $a$.

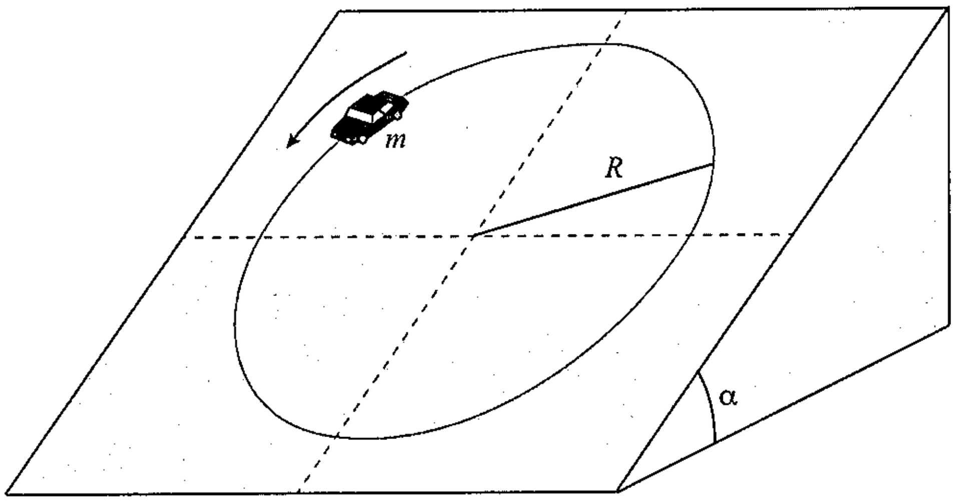



   (a) Find the minimum value, $\mu_{\min}$, of the friction coefficient between the two blocks for which the upper block does not slide on the lower one, so that both move with the same acceleration as the pulley.

   (b) Assume now that the friction coefficient between the two blocks, $\mu$, is smaller than the value found in (a).

   Compute the accelerations of the two blocks in this case.

2. A car of mass $m$ (to be treated as a point particle) is driven on a plane along a circle of radius $R$ at constant speed, $v$. The friction coefficient between the car's tyres and the plane is $\mu$.



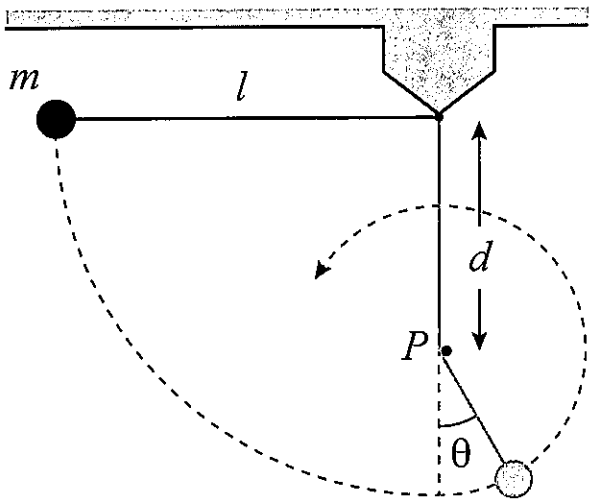

(a) Compute, in terms of $\mu$ and $R$, the maximum speed at which the car can be driven along the circular trajectory if the plane is horizontal.

(b) Assume now that the same car is driven along a circle on a plane tilted at an angle $\alpha$ as shown in the figure. The friction coefficient between the car and the plane is the same as in (a) and the car travels at the same speed, $v$, computed in (a). Determine the minimum value of the radius of the circle that the car can travel along without slipping.

*Hint:*

In part (b) you should identify, based on the directions of the forces on the car, the point along the circle where the car starts to slip when the radius is reduced below the minimum value.

3. A pendulum consists of a point particle of mass $m$ attached to a massless string of length $l$. The particle is held with the string in a horizontal position and released from rest. It swings down until it reaches the lowest point, where the string runs into a fixed peg, $P$, located at distance $d$ below the pivot, see figure.




   (a) Determine the minimum value of $d$ for which the string remains taut at all times as it rotates around $P$.

   *Note:* Assume the diameter of the peg to be negligible, so that the particle moves along a circle about $P$.

   (b) Compute the tension along the string as a function of the angle $\theta$ in the figure after the string hits the peg.

*Hint:*

Weight is the only force doing work on the particle. Therefore you can use energy conservation to compute the speed of the particle.