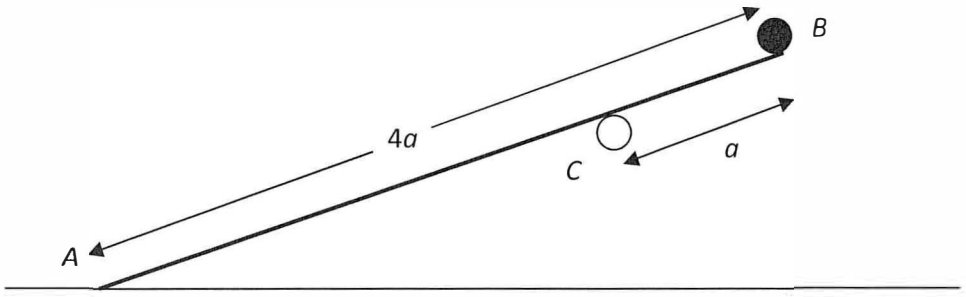
Godalming College

Mechanics 10 – Dynamics, inclined planes, connected particles.

Please **complete** this homework by _____. Start it early. If you can't do a question you will then have time to ask your teacher for help or go to a drop in session.

Section 1 – Review of previous topics.
Please complete all questions.

1) **Figure 1**



A wooden plank AB has mass $4m$ and length $4a$. The end A of the plank lies on rough horizontal ground. A small stone of mass m is attached to the plank at B. The plank is resting on a small smooth horizontal peg C, where $BC = a$, as shown in Figure 2. The plank is in equilibrium making an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$. The coefficient of friction between the plank and the ground is μ. The plank is modelled as a uniform rod lying in a vertical plane perpendicular to the peg, and the stone as a particle.

(a) Show that the reaction of the peg on the plank has magnitude $\frac{16}{5}mg$, **(3)**

(b) Show that $\mu \geq \frac{48}{61}$. **(6)**

(c) State how you have used the information that the peg is smooth. **(1)**

2) The daily maximum temperature T at a weather station in August is found over several years to have a mean of 22.1°C and a standard deviation of 3.86°C. T is modelled by the Normal distribution.

Last year, the maximum daily temperature in a particular week had a mean of 25.6°C.

a) Test whether this week was significantly warmer than usual using a 1% significance level.
b) Find the critical region for the test statistic when using a 10% significance level.

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Section 2 – Consolidation of this week's topic.

Please complete all questions.

1) A block of mass 7kg lies on a rough slope inclined at 35^0 to the horizontal. A string is attached to the block and is pulled with a force of 50N up the slope. The coefficient of friction between the mass and the slope is 0.1. Find the acceleration of the block (to 2 sig figs). **(4)**

2) A box of mass 5kg lies on a rough slope inclined at 40^0 to the horizontal. A light inextensible string is attached to the box. The string passes over a smooth pulley fixed to the top of the slope. The other end of the string is attached to a box of mass 6kg which hangs vertically, 1m above the floor.

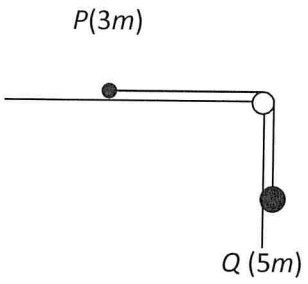
   a) The 6kg mass is released from rest and after 2 sec, it hits the floor. Find the coefficient of friction between the 5kg mass and the slope. **(6)**

   b) Explain how you have used the fact that
      i) the string is light
      ii) the string is inextensible
      iii) the pulley is smooth **(3)**

3) A boy kicks a block of mass 2kg so that it slides up a rough plane inclined at 30^0 to the horizontal. The block has an initial speed of $3ms^{-1}$. The coefficient of friction between the block and the plane is ½.

   a) Show that after it has been kicked, the deceleration of the block up the slope is $9.1ms^{-2}$ to 2 sig figs.
   b) Find the distance travelled by the block before it comes to instantaneous rest.
   c) Find the acceleration of the block as it slides back down the slope.
   d) Show that the block will have a speed of $0.8ms^{-1}$ to 1 sig fig as it returns to the point where it was kicked. **(10)**

4) **Figure 2**



Two particles P and Q have masses $3m$ and $5m$ respectively. They are connected by a light inextensible string which passes over a small smooth light pulley fixed at the edge of a rough horizontal table. Particle P lies on the table and particle Q hangs freely below the pulley, as shown in Fig. 2. The coefficient of friction between P and the table is 0.6. The system is released from rest with the string taut. For the period before Q hits the floor or P reaches the pulley,

(a) write down an equation of motion for each particle separately **(4)**

(b) find, in terms of g, the acceleration of Q **(4)**

(c) find, in terms of m and g, the tension in the string. **(2)**

When Q has moved a distance h, it hits the floor and the string becomes slack. Given that P remains on the table during the subsequent motion and does not reach the pulley,

(d) find, in terms of h, the distance moved by P after the string becomes slack until P comes to rest. **(6)**

5)

Figure 3

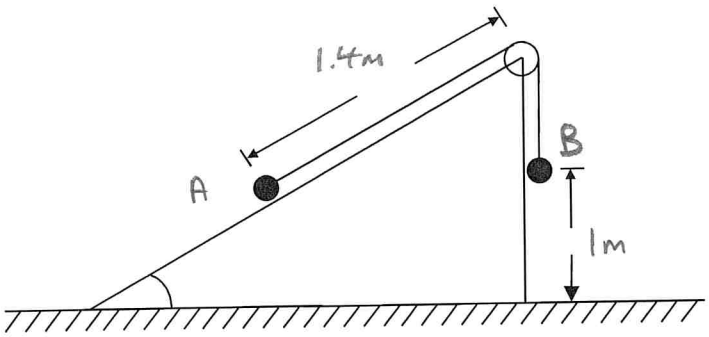


Figure 3 shows two particles A and B, of mass m kg and 0.4 kg respectively, connected by a light inextensible string. Initially A is held at rest on a fixed smooth plane inclined at 30° to the horizontal. The string passes over a small light smooth pulley P fixed at the top of the plane. The section of the string from A to P is parallel to a line of greatest slope of the plane. The particle B hangs freely below P. The system is released from rest with the string taut and B descends with acceleration $\frac{1}{5}g$.

(a) Write down an equation of motion for B. **(2)**

(b) Find the tension in the string. **(2)**

(c) Prove that $m = \frac{16}{35}$. **(4)**

(d) State where in the calculations you have used the information that P is a light smooth pulley. **(1)**

On release, B is at a height of one metre above the ground and AP = 1.4 m. The particle B strikes the ground and does not rebound.

(e) Calculate the speed of B as it reaches the ground. **(2)**

(f) Show that A comes to rest as it reaches P. **(5)**

Total Mark: 55