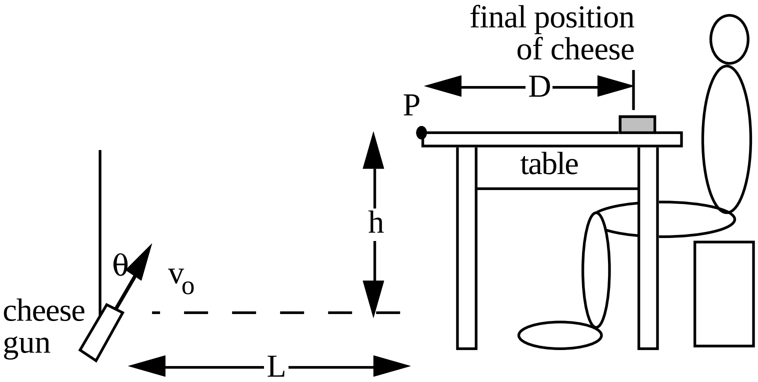
2002 test 1, PHYS 1989-1999

Question 1 (22 marks)



Eccentric inventor Gromit has built a gun that fires pieces of cheese (mass m) at **initial speed v_o,** in the direction the gun is pointed. The end of the gun is a distance h below the top of a table, as shown.

a) The cheese is soft and Gromit wishes it to land it on the table top gently. Derive an expression for the angle θ (with respect to vertical) at which he should he point the gun, so that it reaches the height h with a zero vertical component of velocity. (You may neglect the size of the cheese.)

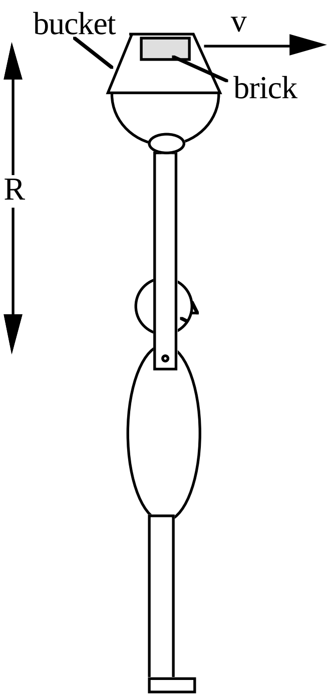
b) The cheese gun is pointed at this angle and Gromit has shaped the cheese so that air resistance is negligible. Derive an expression for the velocity with which the cheese lands on the table, in terms of θ. (Note: give the velocity, not speed).

c) Derive an expression for the distance L from the edge of the table at which he should place the gun so that the cheese lands at point P. Express your answer in terms of θ: you need not relate this to the original parameters of the problem, or try to simplify your answer.

d) The gun is so placed, the cheese lands at point P with zero vertical component of velocity. The cheese then slides a distance D across the table. Determine the work W done by friction in stopping the cheese. Give your answer in terms of v_o and θ.

e) Using the result to (d) or otherwise, determine the coefficient of kinetic friction μ_k between the cheese and the table top that is required to stop the cheese after it has slid the distance D. Give your answer in terms of v_o and θ.

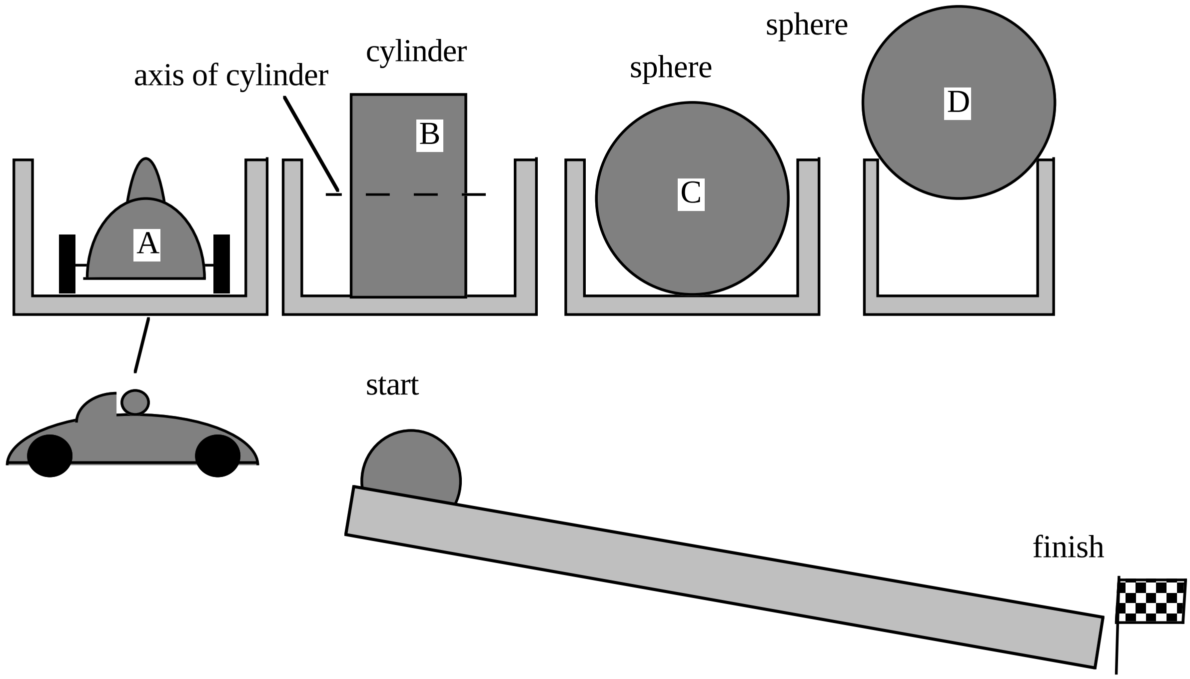
Question 2 (8 marks)



A physics lecturer swings a bucket in a vertical circle, radius R, about his shoulder, as shown. The bucket contains a brick. Determine the minimum speed v that the bucket must have at the top of the circle so that the brick stays in contact with the bucket?

Question 3 (13 marks)

The Australian Grand Prix has been cancelled. You decide to offer an alternative event.



The contestants are two identical brass spheres, a brass cylinder (whose axis is horizontal so it can roll), and a toy racing car. All have the same mass. The wheels of the car are light and they turn with negligible friction on the axle. They roll down four tracks, which are shown in cross section in the top sketch. The tracks are straight, but inclined downwards (all at the same angle). Track A is narrower than the sphere, as shown. The friction between the track and the objects is sufficiently high that the sphere, cylinder and wheels all roll. Air resistance and other losses are negligible.

They race in pairs, and are released from rest at the same time.

You may use without proof $I_{sphere} = \frac{2}{5}mR^2$ and $I_{cylinder} = \frac{1}{2}mR^2$

i) In the first heat, A and B race. Which will win? Explain your answer. (You may use equations if you like, but this is not required. A few clear sentences could be enough.)

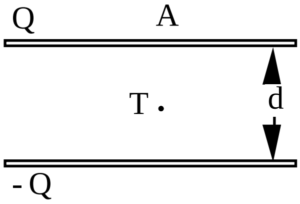
Hint: it may be helpful to state some general principles that will be relevant to all of (i), (ii) and (iii).

ii) In the second heat, B and C race. Which will win? Explain your answer. (Here you probably will need an equation or two, plus some explanation.)

iii) In the third heat, C and D race. Which will win? Explain your answer. (You may use equations if you like, but this is not required. A few clear sentences could be enough.)

Question 4 (15 marks)

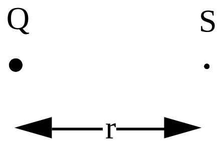
a)



i) Charges Q and – Q are placed on the two plates of a capacitor, with area A and separation d, with no dielectric present. Determine the force on a charge q placed at point T at the middle of the system.

ii) The charge q is removed, and an *uncharged* object is placed at T. Is there a force on the uncharged object and, if so, in which direction is that force? Explain your answer briefly with the aid of a clear, well-labelled diagram.

b)

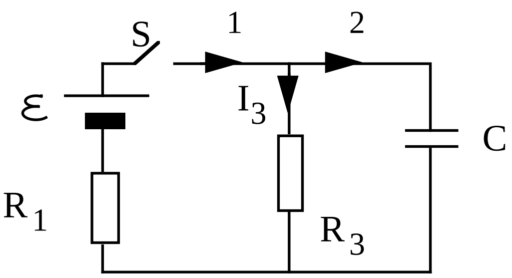


i) Q is the (positive) charge on a small, isolated conductor. What is the force on a charge q placed at point S?

ii) The charge q is removed, and an *uncharged* object is placed at S. Is there a force on the uncharged object and, if so, in which direction is that force? Explain your answer briefly with the aid of a diagram.

iii) With only charge Q and the uncharged object at S present, is there a force on the charge Q? If so, in which direction? Explain your answer in one or two sentences.

Question 5 (13 marks)



In the circuit shown at left, the capacitor C is initially uncharged and the switch S is open.

a) Give expressions for the currents I_1, I_2 and I_3, at a time immediately after the closing of the switch S. Explain briefly how you arrived at your answers.

Hint: this does not require differential equations, and it may be helpful to consider the state of C.

b) Give expressions for the currents I_1, I_2 and I_3, at a time long after the closing of the switch S. Explain briefly how you arrived at your answers.