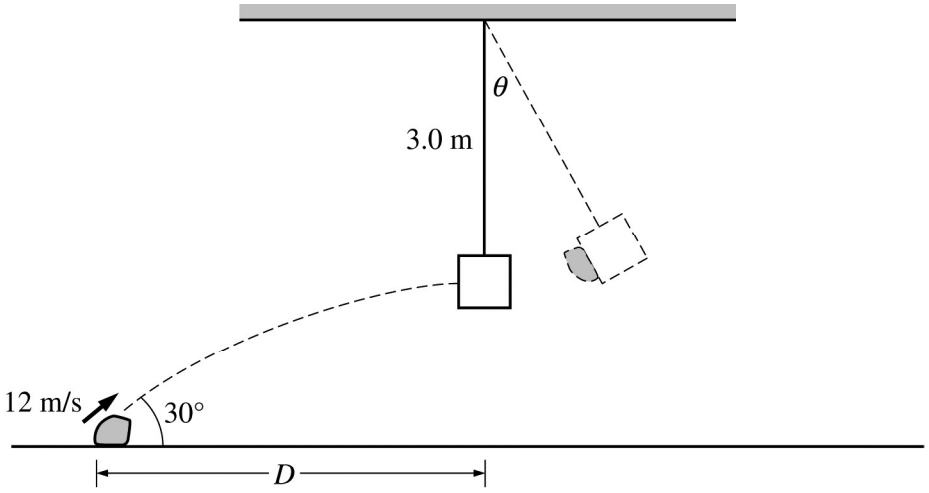
PHYSICS C: MECHANICS
SECTION II
Time—45 minutes
3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.



Mech. 1.
A chunk of clay of mass 0.20 kg is thrown from the ground with an initial speed of 12 m/s at an angle of 30° with the horizontal, as shown above. At the top of its trajectory, the clay strikes a small block of mass 2.3 kg suspended from a 3.0 m long string. The clay sticks to the block, which then swings freely. Neglect air resistance.

(a) Calculate the horizontal distance D between the launching point of the clay and a point on the floor directly below the initial position of the block.

(b) Calculate the speed of the block-clay system immediately after the collision with the clay.

(c) Calculate the angle θ through which the block-clay system will rise before coming momentarily to rest.

(d) Calculate the time between when the block is struck and when it first returns to its original position.

(e) The procedure is repeated with a chunk of clay of greater mass. Indicate whether the new angle θ will be greater than, less than, or the same as that determined in (c).

___ Greater ___ Less ___ The same

Justify your answer.

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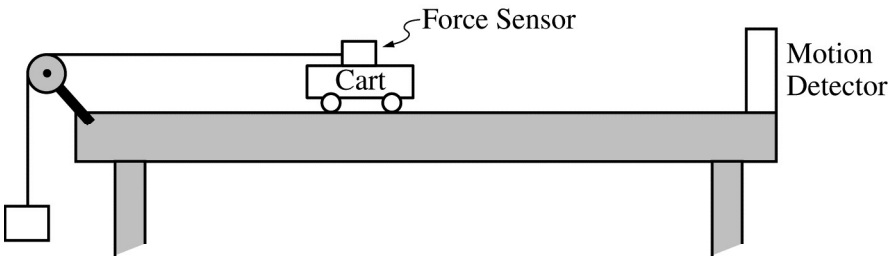


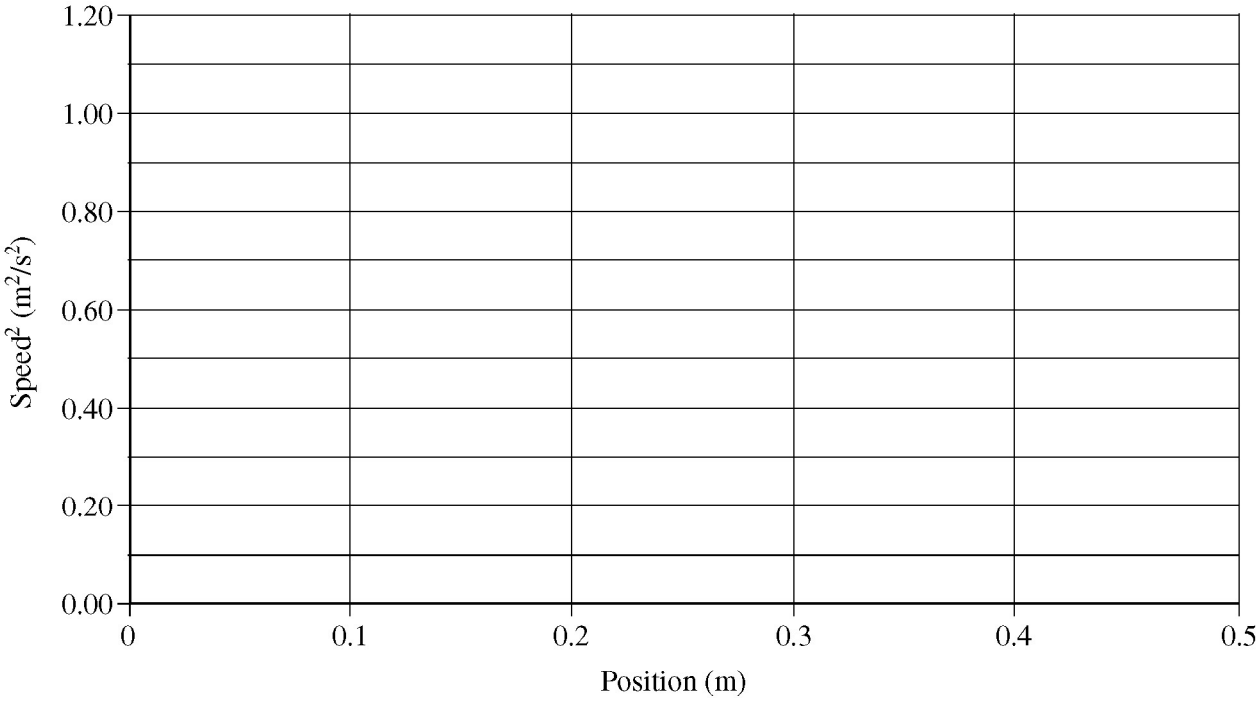
Mech. 2.
In the lab apparatus above, a force sensor attached to a cart is connected by a string to a block. The string passes over a pulley. The block is allowed to fall, accelerating the cart. A computer attached to the force sensor and a motion detector displays the position, the speed, and the force applied to the cart at five different locations, as given in the table below. The square of the speed is also provided.

Position (m)	Speed (m/s)	Force (N)	Speed^2 $\left(m^2/s^2\right)$
0.00	0.55	0.84	0.30
0.10	0.66	0.85	0.44
0.20	0.85	0.84	0.73
0.30	0.94	0.83	0.88
0.40	1.08	0.85	1.17

(a) i. Determine the average force exerted by the string.

ii. Estimate the work done by the average force on the cart during the time that data was taken.

(b) i. On the axes below, graph the square of the speed versus position.



ii. Draw a best-fit line through the points.

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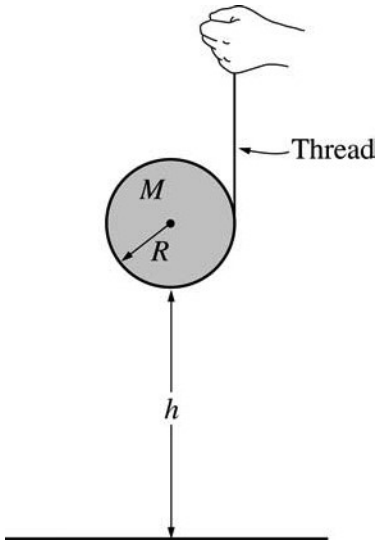
(c) Calculate the acceleration of the cart from the best-fit line.

The mass of the cart is 0.65 kg.

(d) Use a method different from that used in (a) ii. to calculate the work done on the cart from the data given.

(e) Indicate whether the values you obtained in (a) and (d) are in agreement. If they are, explain why they should be. If they are not, indicate a possible cause of the discrepancy.



Mech. 3.
A student holds one end of a thread, which is wrapped around a cylindrical spool, as shown above. The student then drops the spool from a height h above the floor, and the thread unwinds as it falls. The spool has a mass M and a radius R, and the thread has negligible mass. The spool can be approximated as a solid cylinder of moment of inertia $I = \frac{1}{2}MR^2$. Express your answers in terms of M, R, h, and fundamental constants.

(a) Calculate the linear acceleration of the spool as it falls.

(b) Calculate the angular velocity of the spool just before it strikes the floor.

At time $t = 0$, the spinning spool lands on the floor without bouncing and comes free from the thread. It continues to spin, but slips on the floor's surface while doing so. Assume a constant coefficient of sliding friction μ.

(c) Calculate the angular velocity of the spool as a function of time t.

(d) Calculate the horizontal speed of the spool as a function of time, assuming the horizontal speed is zero at time $t = 0$.

(e) At what time does slipping between the spool and floor cease?

STOP

END OF EXAM