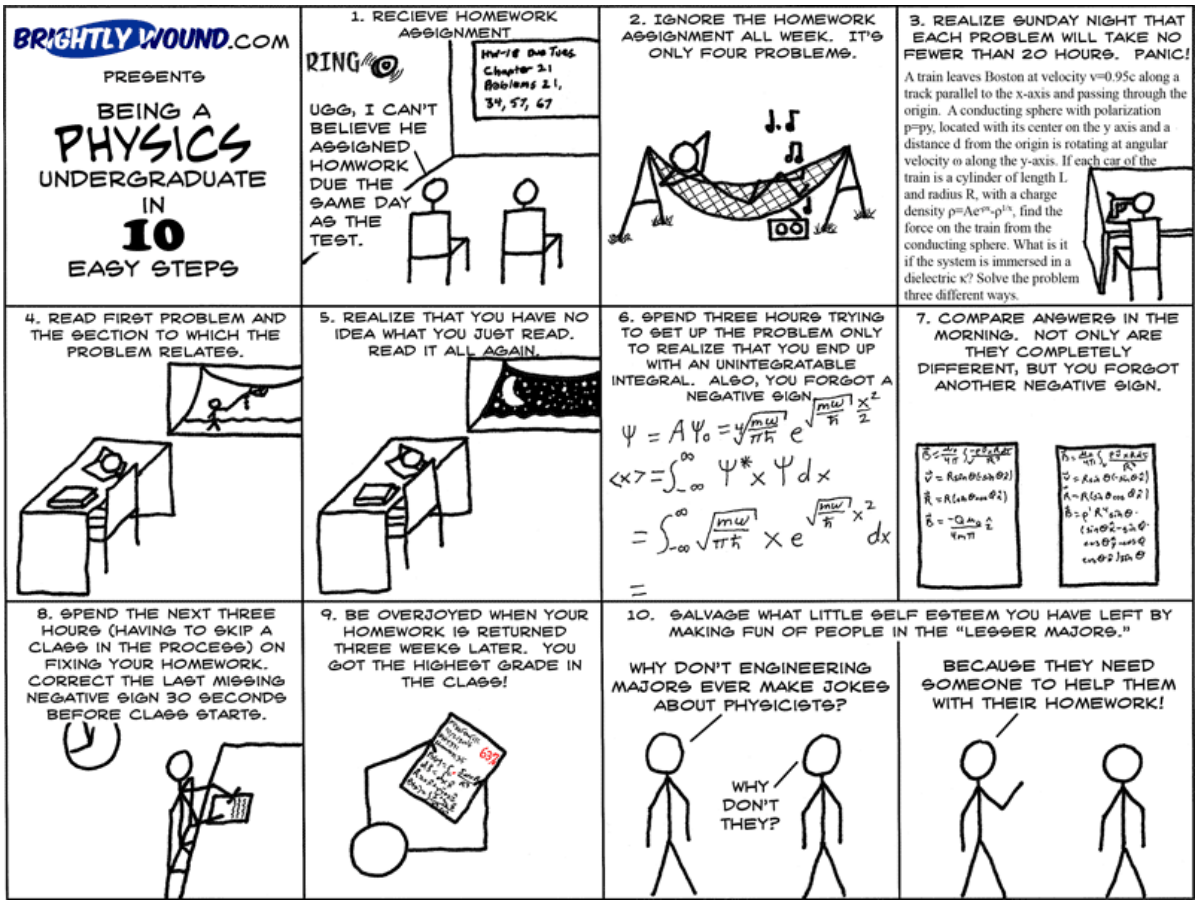
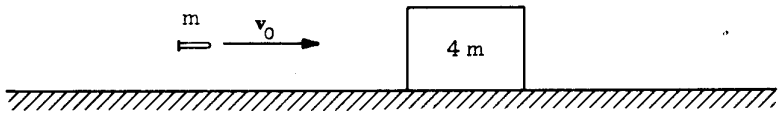
Energy in Collisions Problems
AP Physics C

Name _____





1. A bullet of mass m and velocity v_0 is fired toward a block of mass 4m. The block is initially at rest on a frictionless horizontal surface. The bullet penetrates the block and emerges with a velocity of $\frac{v_o}{3}$

(a) Determine the final speed of the block.

$v_f = 1/6v_0$

(b) Determine the loss in kinetic energy of the bullet.

$\Delta K_{bullet} = -4/9mv_0^2$

(c) Determine the gain in the kinetic energy of the block.

$\Delta K_{block} = +1/18mv_0^2$

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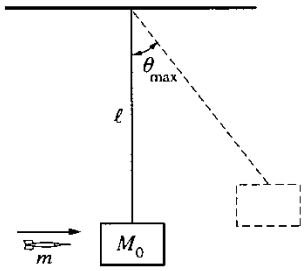

1999M1 In a laboratory experiment, you wish to determine the initial speed of a dart just after it leaves a dart gun. The dart, of mass m, is fired with the gun very close to a wooden block of mass M_0 which hangs from a cord of length *l* and negligible mass, as shown above. Assume the size of the block is negligible compared to *l*, and the dart is moving horizontally when it hits the left side of the block at its center and becomes embedded in it. The block swings up to a maximum angle from the vertical. Express your answers to the following in terms of m, M_0, *l*, θ_{max}, and g.

a. Determine the speed v_0 of the dart immediately before it strikes the block.

b. The dart and block subsequently swing as a pendulum. Determine the tension in the cord when it returns to the lowest point of the swing.

c. At your lab table you have only the following additional equipment.

Meter stick	Stopwatch	Set of known masses
Protractor	5 m of string	Five more blocks of mass M_0
Spring		

Without destroying or disassembling any of this equipment, design another practical method for determining the speed of the dart just after it leaves the gun. Indicate the measurements you would take, and how the speed could be determined from these measurements.

d. The dart is now shot into a block of wood that is fixed in place. The block exerts a force **F** on the dart that is proportional to the dart's velocity **v** and in the opposite direction, that is $\mathbf{F} = -b\mathbf{v}$, where b is a constant. Derive an expression for the distance L that the dart penetrates into the block, in terms of m, v_0, and b.

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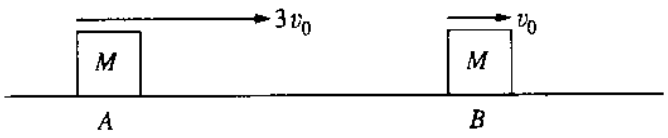

2. Two identical objects A and B of mass M move on a one-dimensional, horizontal air track. Object B initially moves to the right with speed v_o. Object A initially moves to the right with speed $3v_o$, so that it collides with object B. Friction is negligible. Express your answers to the following in terms of M and v_o.

a. Determine the total momentum of the system of the two objects.

b. A student predicts that the collision will be totally inelastic (the objects stick together on collision). Assuming this is true, determine the following for the two objects immediately after the collision.

i. The speed

$v = 2v_0$

ii. The direction of motion (left or right)

When the experiment is performed, the student is surprised to observe that the objects separate after the collision and that object B subsequently moves to the right with a speed $2.5v_o$.

c. Determine the following for object A immediately after the collision.

i. The speed

$v = 1.5v_0$

ii. The direction of motion (left or right)

d. Determine the kinetic energy dissipated in the actual experiment.

$\Delta K = -3/4Mv_0^2$

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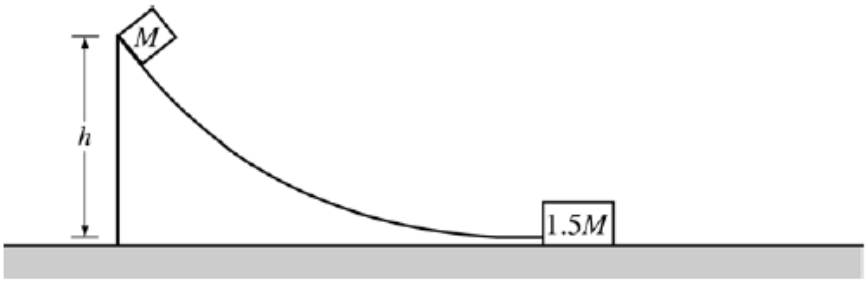

3. A small block of mass *M* is released from rest at the top of the curved frictionless ramp shown above. The block slides down the ramp and is moving with a speed $3.5v_0$ when it collides with a larger block of mass $1.5M$ at rest at the bottom of the incline. The larger block moves to the right at a speed $2v_0$ immediately after the collision. Express your answers to the following questions in terms of the given quantities and fundamental constants.

(a) Determine the height *h* of the ramp from which the small block was released.

$h = 6.125v_0^2/g$

(b) Determine the speed of the small block after the collision.

$v_1 = 0.5v_0$

(c) The larger block slides a distance *D* before coming to rest. Determine the value of the coefficient of kinetic friction μ between the larger block and the surface on which it slides.

$$\mu = \frac{3v_0^2}{gD}$$

(d) Indicate whether the collision between the two blocks is elastic or inelastic. Justify your answer.

$3Mv_0^2$ of mechanical energy is lost