807 AP Physics

Schmidt

Name: ________________

Block: ________

U5H3

Conservation of Momentum (with C.O.E., Elastic collisions, explosions)

$m_A\vec{v}_{A0} + m_B\vec{v}_{B0} = m_A\vec{v}_{A1} + m_B\vec{v}_{B1}$ *(all collisions)*; $\frac{1}{2}m_A v_{A0}^2 + \frac{1}{2}m_B v_{B0}^2 = \frac{1}{2}m_A v_{A1}^2 + \frac{1}{2}m_B v_{B1}^2$ *(Elastic only)*

$\vec{v}_{A0} - \vec{v}_{B0} = \vec{v}_{B1} - \vec{v}_{A1}$ *(Elastic only)* v may be positive or negative

1. A body of mass 8 kg is traveling at 2 m/s with no external force acting. At a certain instant an internal explosion occurs, splitting the body into two chunks of 4 kg mass each. The explosion gives the chunks an additional 16 J of kinetic energy. Neither chunk leaves the line of original motion. Determine the speed and direction of motion of each of the chunks after the explosion. (4m/s; 0m/s)

2. A bullet of mass 10g strikes a ballistic pendulum of mass 2.0 kg. The center of mass of the pendulum rises a vertical distance of 12 cm. Assuming that the bullet remains embedded in the pendulum, calculate the bullet's initial speed. (312 m/s)

3. A 20 kg wood ball hangs from a 2.0 m long wire which will break if the tension in the wire exceeds 400 N. A 1.0 kg projectile travelling horizontally hits and embeds itself in the wood ball. What is the largest speed the projectile can have without causing the cable to break? (89.3 m/s)

4. A small block of mass $m_1 = 0.5$ kg is released from rest at the top of a curved frictionless wedge of mass $m_2 = 3$ kg. The wedge sits on a frictionless surface and is <u>free to move</u>. When the block leaves the wedge, its velocity is 4 m/s to the right (horizontally). (a) What is the velocity of the wedge after the block reaches the horizontal surface? (b) What is the height of the wedge? (0.66 m/s to the left; 0.93m)

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5. A cart with mass 340 g moving on a frictionless linear air track at an initial speed of 1.2 m/s collides with a second cart of unknown mass at rest. The collision between the carts is elastic. After the collision, the first cart continues in its original direction at 0.66m/s. (a) What is the mass of the second cart? (b) What is its speed after the impact? (99 g, 1.9m/s)

6. A steel ball of mass 0.5 kg is fastened to a cord 70 cm long and fixed at the far end, and is released when the cord is horizontal. At the bottom of its path, the ball strikes a 2.5 kg steel block initially at rest on a frictionless surface. The collision is elastic. Find (a) the speed of the ball and (b) the speed of the block, both just after the collision. (-2.47m/s, 1.23m/s)

7. You have been asked to design a 'ballistic spring system' to measure the speed of bullets. A bullet of mass m is fired into a block of mass M. The block, with the embedded bullet, then slides across a frictionless table and collides with a horizontal spring whose spring constant is k. The opposite end is anchored to a wall. The spring's max. compression d is measured.

(a) Find the bullet's speed v_B in terms of m, M, k and d ($\frac{(m+M)}{m}\sqrt{\frac{kd^2}{(m+M)}}$)

(b) What was the speed of a 5.0 g bullet if the block's mass is 2.0 kg and if the spring, with k = 50 N/m, was compressed by 10 cm? (200m/s)

(c) What fraction of the bullet's initial energy is lost? (99.75% lost)

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8. A spring, whose spring constant is 50 N/m is suspended from the ceiling. A block of 2kg hangs from the spring. A bullet with a mass of 10 g is fired vertically upward directly beneath the block with a time dependent force of $t^2 + 2t + 5$. The force on the bullet lasts for 0.5 s. The bullet collides with the block and becomes embedded into the block. How far upwards does the block/bullet rise?

(0.28m)

9. A 75 kg firefighter slides down a pole while a constant frictional force of 300 N impedes her motion. A horizontal 20.0 kg platform is supported by a spring at the bottom of the pole to cushion her fall. The firefighter starts from rest 4.00 m above the platform, and the spring constant is 4000 N/m. Find (a) the firefighter's speed immediately before she collides with the platform and (b) the maximum compression of the spring. Assume the friction acts during the entire motion.

(6.9 m/s; 1.01m)

10. A crash test car of mass 1,000 kg moving at constant speed of 12 m/s collides completely inelastically with an object of mass M at time t = 0. The object was initially at rest. The speed v in m/s of the car-object system after the collision is given as a function of time t in seconds by the expression

$$v(t) = \frac{8}{1+5t}$$

(a) Calculate the mass M of the object. (M=500 kg)

(b) Assuming an initial position of x = 0, determine an expression for the position of the car-object system after the collision as a function of time t. $x(t) = \frac{8}{5}\ln(1+5t)$

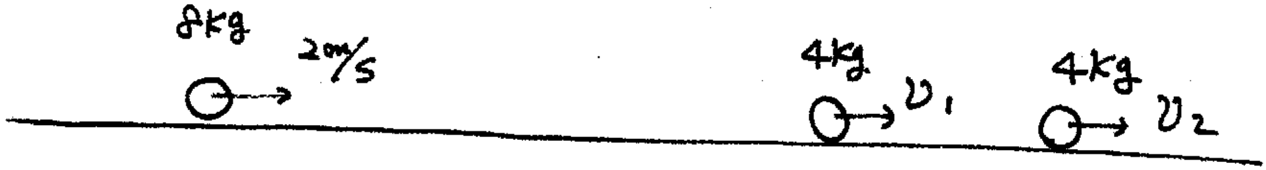
(c) Determine an expression for the resisting force on the car-object system after the collision as a function of time t

$$F(t) = -\frac{60{,}000}{(1+5t)^2}$$

(d) Determine the impulse delivered to the car-object system from t = 0 to t = 2 s. (-10,909 Ns)

U5H3.

1.



① $\Sigma mv = 16.$ $\Sigma mv = 4v_1 + 4v_2.$

$\therefore 16 = 4v_1 + 4v_2$

$4 = v_1 + v_2$

② $K.E. = \frac{1}{2} \times 8 \times 4$

$= 16 \text{ J}$

$KE. = \frac{1}{2} \times 4 v_1^2 + \frac{1}{2} \times 4 \times v_2^2$

$= 2v_1^2 + 2v_2^2$

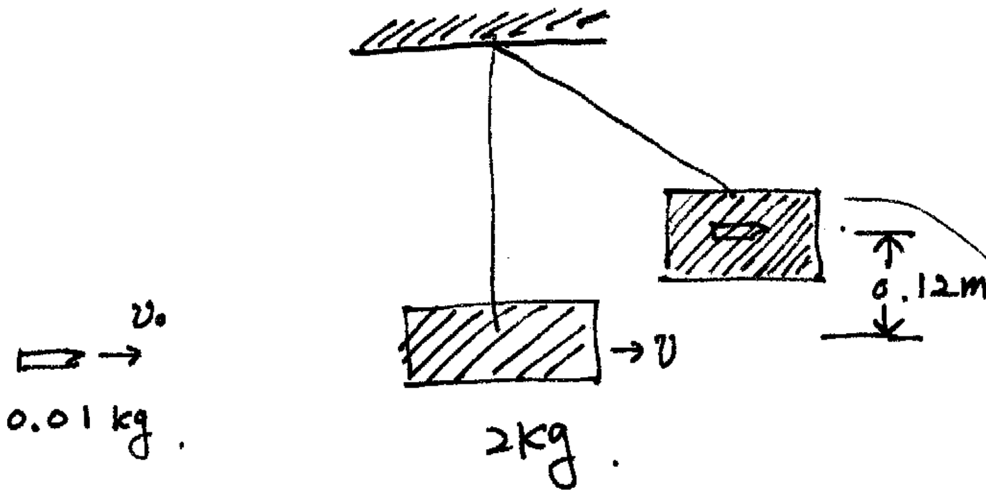
$32 = 2v_1^2 + 2v_2^2$

$16 = v_1^2 + v_2^2.$

$\therefore \begin{cases} v_1 = 0 \\ v_2 = 4 \text{ m/s}. \end{cases}$ or $\begin{cases} v_1 = 4 \text{ m/s} \\ v_2 = 0. \end{cases}$

U5H3.

2.



Before.

Σmv

$= 0.01 \times v_0$

$= 0.01 v_0$

After.

Σmv

$= 2.01 \times v$

$$\boxed{0.01 v_0 = 2.01 v}$$

mgh

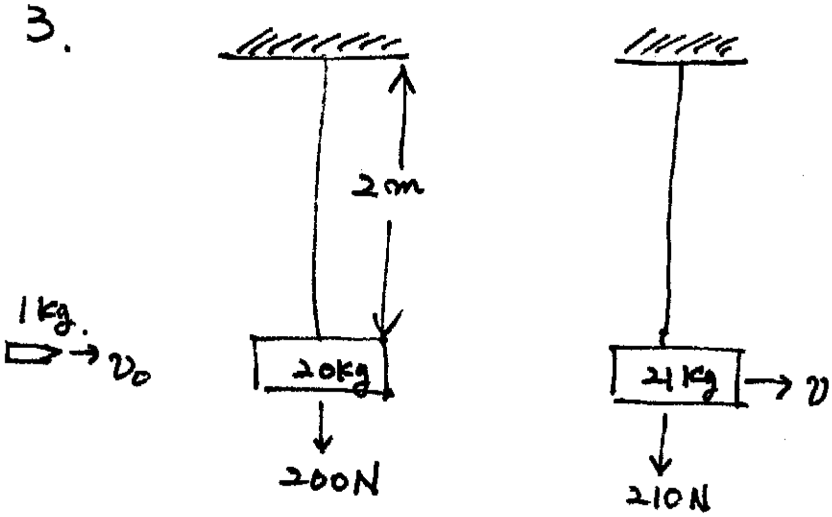
$$\frac{1}{2} \times \cancel{2.01} \times v^2 = \cancel{2.01} \times 10 \times 0.12$$

$$v = \sqrt{2 \times 10 \times 0.12} = 1.55 \text{ m/s}$$

$$v_0 = \frac{2.01}{0.01} \times 1.55 = 311.6 \text{ m/s}$$

W5H3

3.



① $\Sigma mv = v_0 = 21 \cdot v = 89.331 \ m/s$

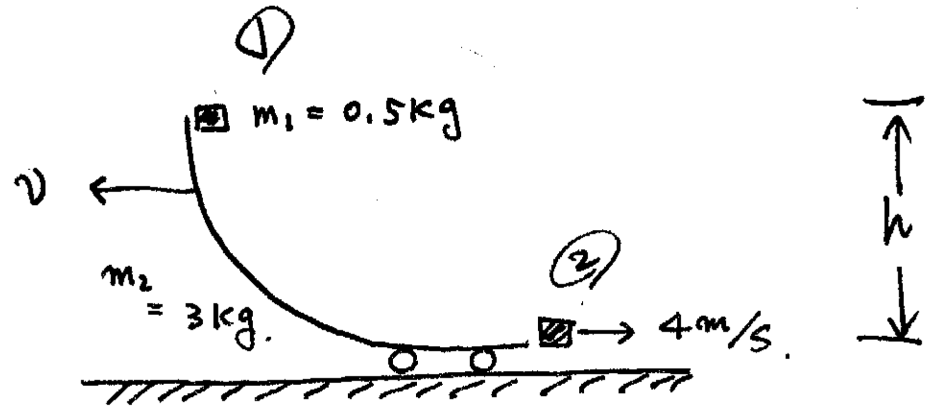
② $\text{Tension} = 210 + 21 \dfrac{v^2}{2} = 400$

$$v = \sqrt{\frac{400-210}{21} \times 2.}$$

$= 4.2538.$

U5H3.

4.



(a) Before.

$\Sigma mv = 0$

After

$= \Sigma mv = 0.5 \times 4 - 3 \times v$

$0 = 2 - 3v$

$\therefore v = \frac{2}{3}$ m/s.

(b) $Total = mgh + \frac{1}{2}mv^2 = 0.5 \times 10 \times h$ ⓐ 1

$Total\ E = mgh + \frac{1}{2}mv^2 = \frac{1}{2} \times 0.5 \times 16$ ⓐ 2.

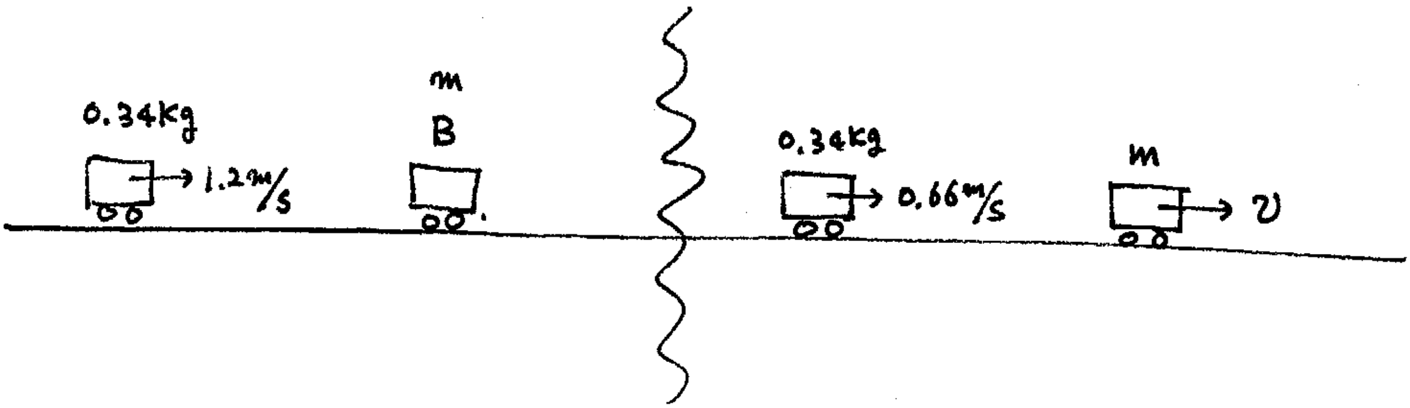
$E = \frac{1}{2} \times 0.5 \times 16 + \frac{1}{2} \times 3 \times \left(\frac{2}{3}\right)^2 = 4.67.$

$5h = 4.67$

$h = 0.93$ m

U5H3.

5.



① $\Sigma m v = 0.34 \times 1.2 = 0.408 = 0.34 \times 0.66 + m v$.

$$m v = 0.1836$$

② $KE = \frac{1}{2} \times 0.34 \times 1.2^2 = 0.2448 = \frac{1}{2} \times 0.34 \times 0.66^2 + \frac{1}{2} m v^2$

$$0.17075 \times 2 = m v^2$$

$$m v^2 = 0.3415.$$

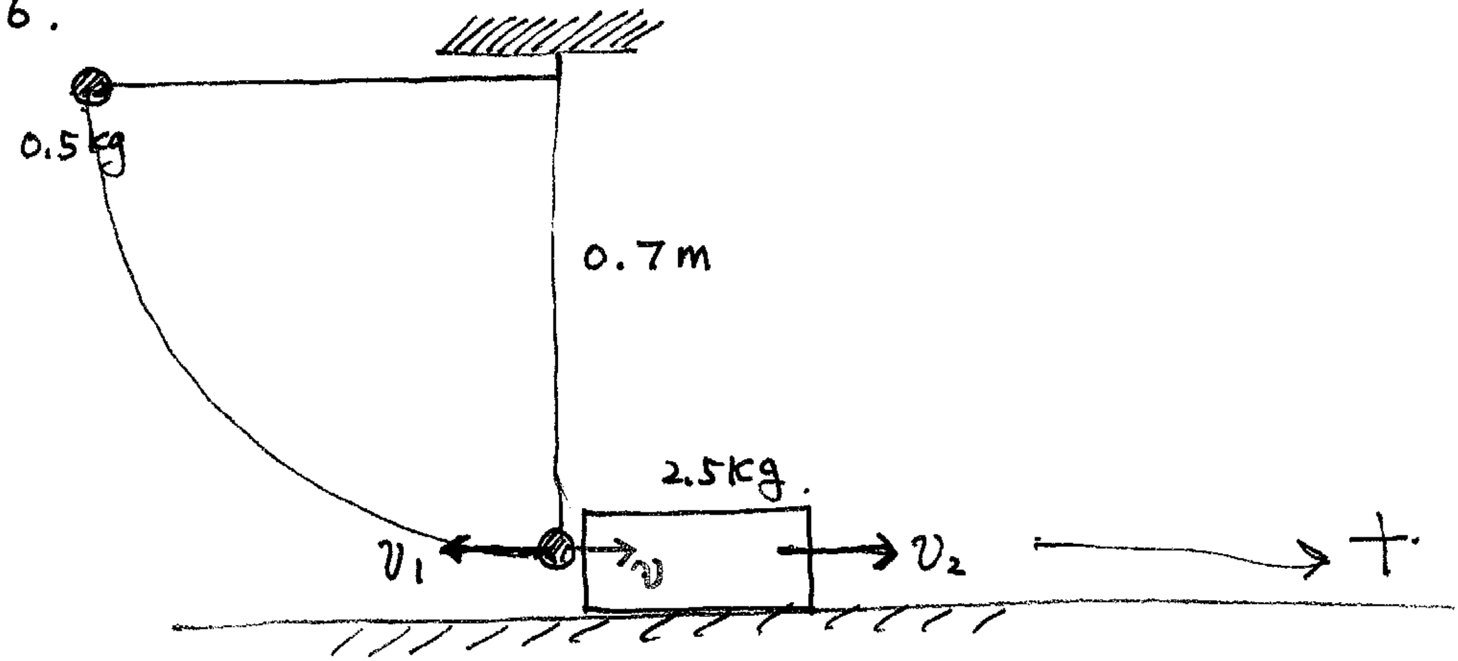
$$m v \cdot v = 0.3415$$

$$v = \frac{0.3415}{0.1836} = 1.86 \text{ m/s}.$$

$$\therefore \quad m = \frac{0.1836}{1.86} = 0.09871 \text{ kg}.$$

U5H3.

6.



Before

Σmv

$= 0.5 \times \underline{\underline{v}} = 1.87$

After

Σmv

$= 2.5 v_2 - 0.5 v_1$

$mgh = \cancel{0.5} \times \cancel{10} \times 0.7 = \frac{1}{2} \times \cancel{0.5} \times v^2$

$v = 3.74$ m/s.

$$2.5 v_2 - 0.5 v_1 = 1.87$$

$KE. = \frac{1}{2} \times 0.5 \times 3.74^2$

$= 3.5$ J

$KE. = \frac{1}{2} \times 0.5 \times v_1^2 + \frac{1}{2} \times 2.5 \times v_2^2$

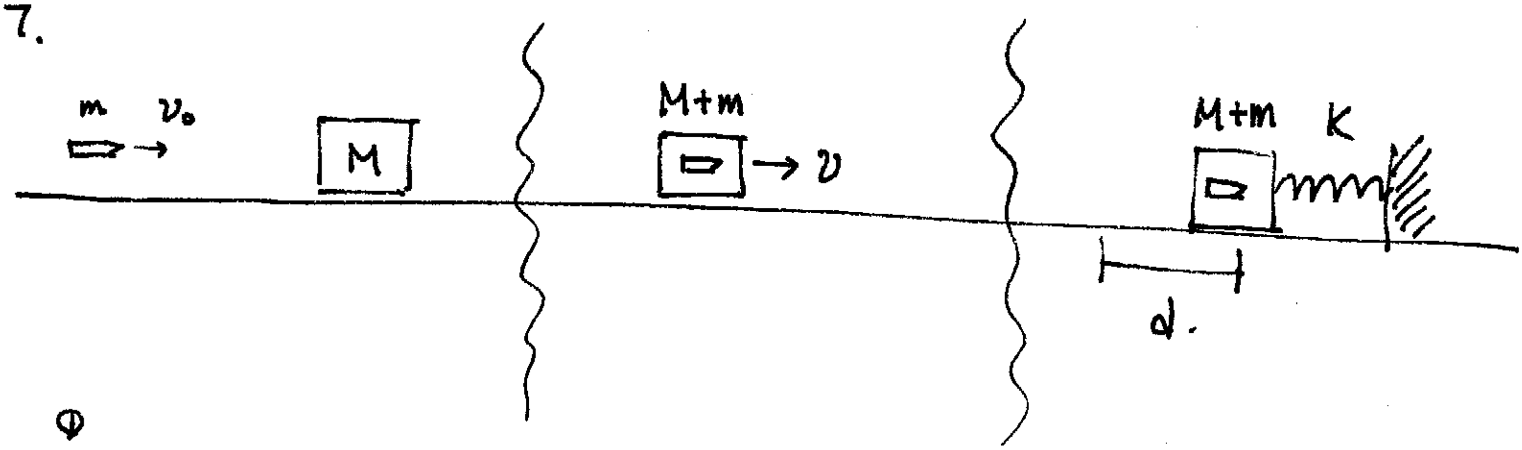
$$3.5 = 0.25 v_1^2 + 1.25 v_2^2$$

$v_1 = 2.5$ m/s

$v_2 = 1.25$ m/s.

W5 H3.

7.



(a) ① $\Sigma m v = m v_0 = (M+m) v$

②

$$\frac{1}{2}(M+m)v^2 = \frac{1}{2}k d^2$$

$$v = \sqrt{\frac{k d^2}{M+m}}$$

$$\therefore v_0 = \frac{(M+m)}{m}\sqrt{\frac{k d^2}{M+m}}$$

(b). $m = 0.005\,kg$ $M = 2\,kg$ $K = 50\,N/m$ $d = 0.1\,m$

$$v_0 = \frac{2.005}{0.005}\sqrt{\frac{50 \times 0.1^2}{2.005}} = 200.25\ m/s.$$

(c). $$\frac{1}{2} m \frac{(M+m)^2}{m^2} \frac{k d^2}{M+m} = \frac{(M+m) k d^2}{2m} = \frac{M+m}{m} \frac{1}{2} k d^2$$

$$= \frac{2.005}{0.005} \left(\frac{1}{2}kd^2\right)$$

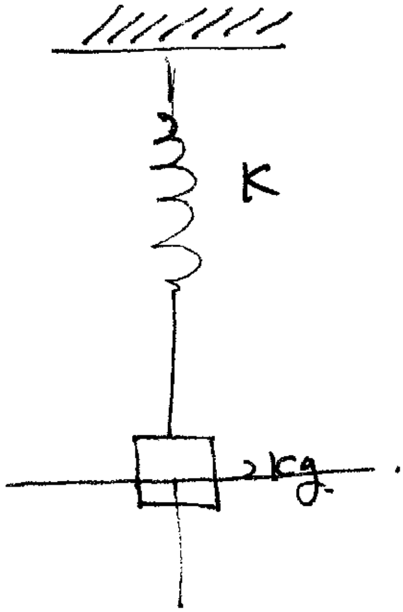
$$= 401 \left(\frac{1}{2}kd^2\right)$$

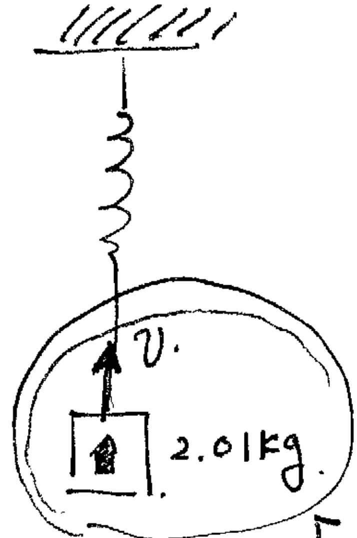
$\frac{1}{2} k d^2$.

$$\frac{(401 - 1)}{401} = \frac{400}{401} = 99.8\,\%.$$

U5H3

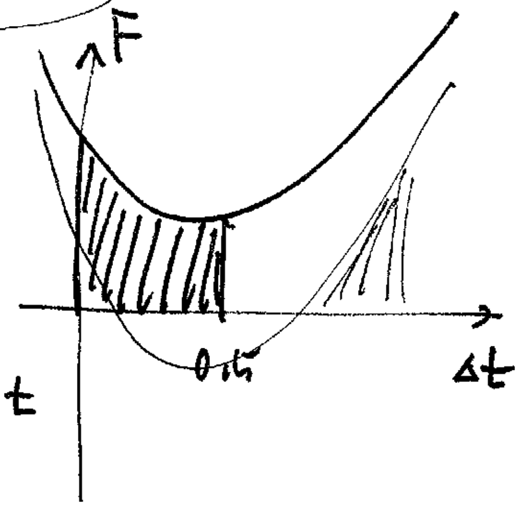
8 $K = 50\ N/m$.





↑ 0.01 kg

$f(t) = t^2 + 2t + 5$



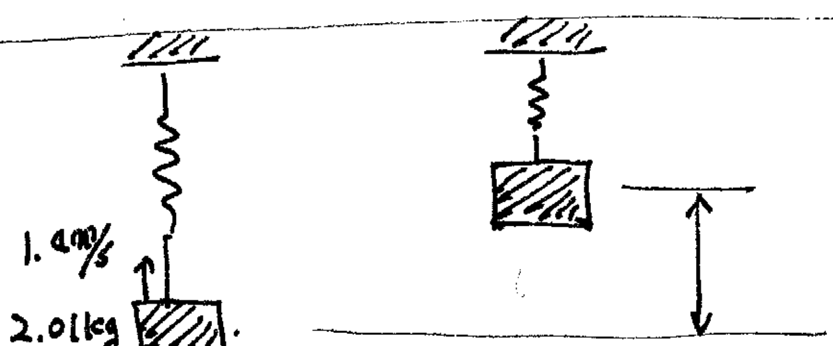
$$\text{Impulse} = F \cdot \Delta t = \int_0^{0.5} (t^2 + 2t + 5)\,dt$$

$$= 2.7917\ N \cdot sec.$$

$\Delta mv = $ Impulse.

$\Delta mv = 2.01 \times v - 0 = 2.7917$

$v = 1.4\ m/s$



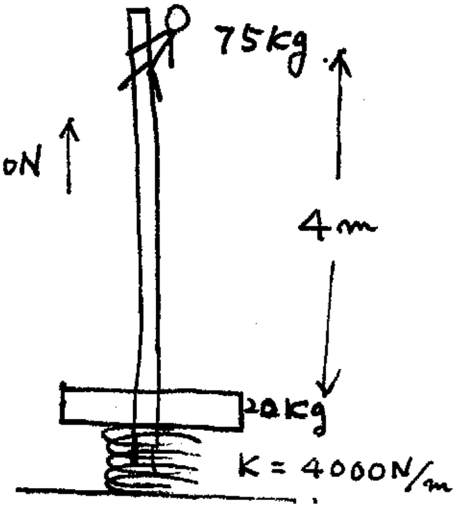
$KE = \frac{1}{2} \times 2.01 \times 1.4^2$

$= 1.97\ J.$

$PE_{spring} = \frac{1}{2} \times 50 \times x^2$

$x = 0.28\ m$

9.



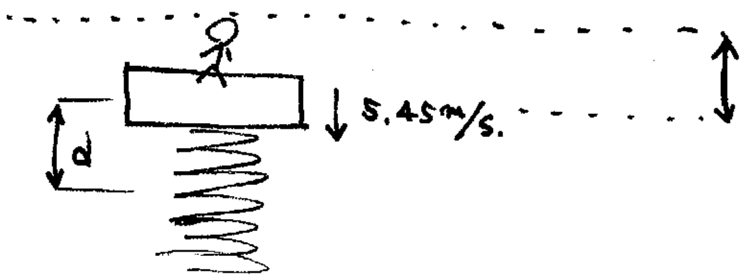
(a) $mgh = 300 \times 4 + \frac{1}{2} m v^2$

$750 \cdot 4 = 1200 + \frac{1}{2} \times 75 \times v^2$.

$v = 6.9$ m/s.

(b) Σmv = 75 × 6.9 = •95 × v
Before after

$v = 5.45$ m/s.



F = Kx.

$\frac{200}{4000} = x = 0.05$ m.

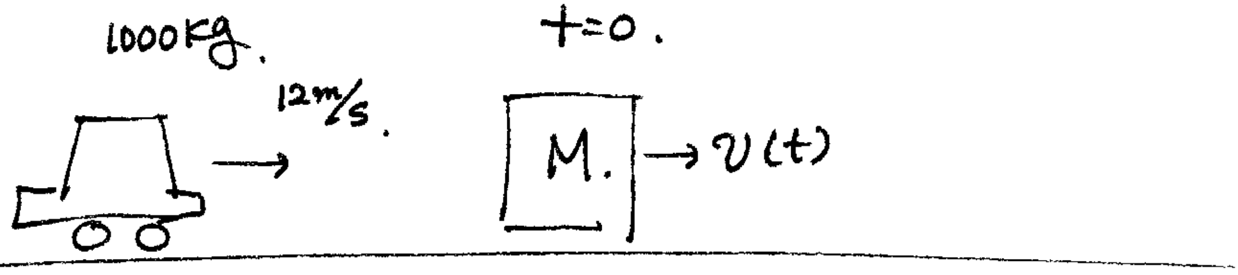
$750 \cdot 4 = 300 \times 4 + \frac{1}{2} \times 4000 \times d^2$

$d = 0.95$ m.

∴ total = 0.95 + 0.05 = 1.0 m.

U5H3.

10.



$v(0) = 8$

$$v(t) = \frac{8}{1+5t}$$

(a).

Before

ΣMv

$= 1000 \times 12$

$= 12000$

After.

$\Sigma mv = (1000 + M)\,8$

$$\frac{12000}{8} - 1000 = M = 500\text{ kg}.$$

(b).

$$x(t) = \int_0^t v(t)\,dt$$

$$= \int \frac{8}{1+5t}\,dt = \frac{8}{5} \cdot \int \frac{5}{1+5t}\,dt$$

$$= \frac{8}{5} \ln|1+5t| \Big]_0^t$$

$$= \frac{8}{5} \left\{ \ln(1+5t) \right\},$$

(c) ~~Impulse = $F \cdot \Delta t$ = Δmv.~~ $\left(\frac{u}{v}\right)' = \frac{u'v - u\ldots}{v^2}$

$$\boxed{F = ma.}$$

$$v(t)' = a(t)$$

$$= \frac{\emptyset - 8(5)}{(1+5t)^2}.$$

$$a(t) = \frac{-40}{(1+5t)^2}$$

$$F = 1500 \times \frac{-40}{(1+5t)^2} = \frac{-60000}{(1+5t)^2}$$

(d) Impulse = $F \cdot \Delta t$

$$= \int_0^2 \frac{-60000}{(1+5t)^2}\, dt = -10909 \text{ N}\cdot\text{s}$$