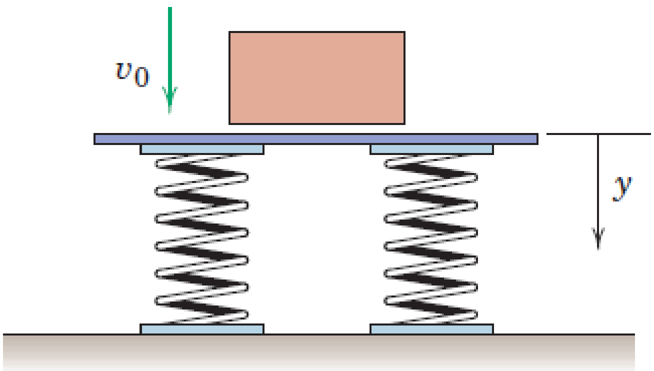
ME 206 – DYNAMICS – SPRING 2017
STUDY PROBLEMS-1

PROBLEM 2/39

The body falling with speed v_0 strikes and maintains contact with the platform supported by a nest of springs. The acceleration of the body after impact is $a = g - cy$, where c is a positive constant and y is measured from the original platform position. If the maximum compression of the springs is observed to be y_m, determine the constant c.



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$$a = g - cy = v\frac{dv}{dy}$$

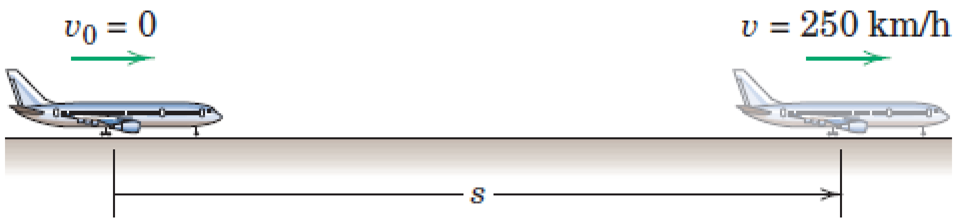
$$\int_0^{y_m} (g - cy)\,dy = \int_{v_0}^{0} v\,dv$$

$$\left(gy - c\frac{y^2}{2}\right)\Big|_0^{y_m} = \frac{v^2}{2}\Big|_{v_0}^{0}$$

$$gy_m - c\frac{y_m^2}{2} = -\frac{v_0^2}{2} \Rightarrow c = \frac{v_0^2 + 2gy_m}{y_m^2}$$

PROBLEM 2/53

On its takeoff roll, the airplane starts from rest and accelerates according to $a = a_0 - kv^2$, where a_0 is the constant acceleration resulting from the engine thrust and $-kv^2$ is the acceleration due to aerodynamic drag. If $a_0 = 2\ \text{m/s}^2$, $k = 0.00004\ \text{m}^{-1}$, and v is in meters per second, determine the design length of runway required for the airplane to reach the takeoff speed of 250 km/h if the drag term is (a) excluded and (b) included.



2/53 (a) $a = 2\ \text{m/s}^2 = \text{constant}$

With $v = 250/3.6 = 69.4$ m/s, we have

$v^2 - v_0^2 = 2a(s - s_0)$: $69.4^2 - 0^2 = 2(2)s$

$$\underline{s = 1206\ \text{m}}$$

(b) $a = a_0 - kv^2 = v\dfrac{dv}{ds}$

$$\int_0^s ds = \int_0^v \frac{v\,dv}{a_0 - kv^2}$$

$$s = -\frac{1}{2k}\ln\left(a_0 - kv^2\right)\Big|_0^v$$

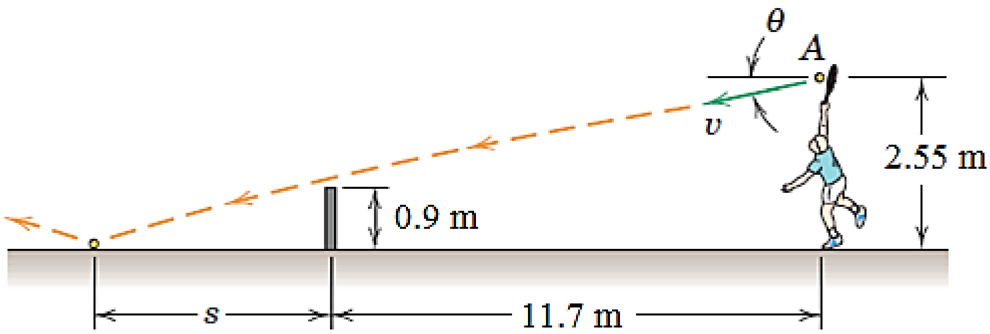
$$= -\frac{1}{2k}\ln\left[\frac{a_0 - kv^2}{a_0}\right]$$

$$s = -\frac{1}{2(4)(10^{-5})}\ln\left[\frac{2 - 4(10^{-5})(69.4)^2}{2}\right]$$

$$= \underline{1268\ \text{m}}$$

PROBLEM 2/77

If the tennis player serves the ball horizontally ($\theta = 0$), calculate its velocity v if the center of the ball clears the 0.9 m net by 0.15 m. Also find the distance s from the net to the point where the ball hits the court surface. Neglect air resistance and the effect of ball spin.



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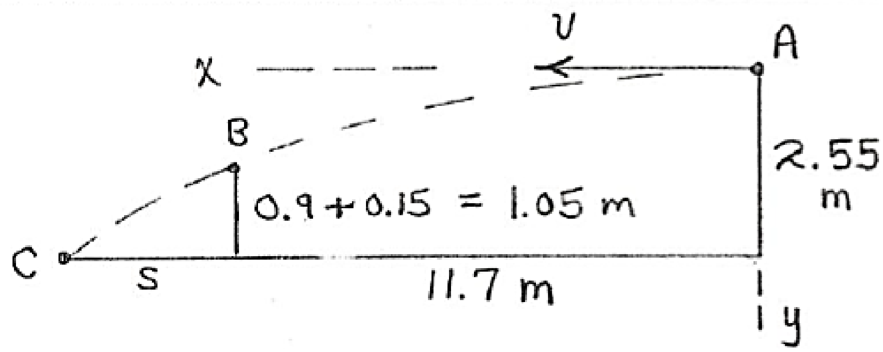


$a_x = 0: \quad x = v_{x_0} t, \qquad 11.7 = v t_B$

$a_y = g: \quad y = v_{y_0} t + \frac{1}{2} g t^2$

At B: $(2.55 - 1.05) = 0 + \frac{1}{2} 9.81 t_B^2, \quad t_B = 0.553$ s

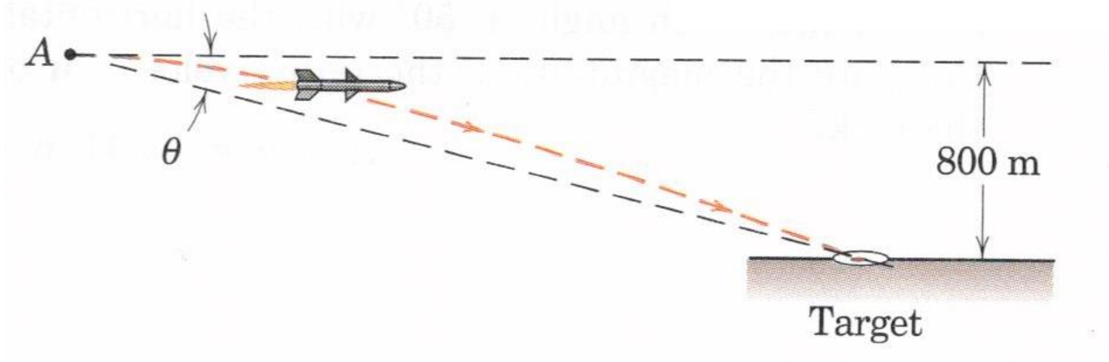
Then $v = \frac{11.7}{t_B} = \frac{11.7}{0.553} = \underline{21.2 \text{ m/s}}$

At C: $2.55 = \frac{1}{2}(9.81) t_C^2, \quad t_C = 0.721$ s

$s + 11.7 = 21.2(0.721), \quad \underline{s = 3.55 \text{ m}}$

PROBLEM 2/78 (6th Edition)

A rocket is released at point A from a jet aircraft flying horizontally at 1000 km/h at an altitude of 800 m. If the rocket thrust remains horizontal and gives the rocket a horizontal acceleration of $0.5g$, determine the angle θ from the horizontal to the line of sight to the target.



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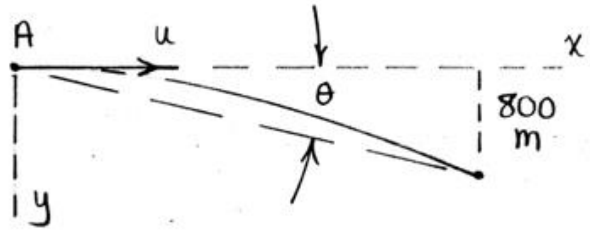
$$u = \frac{1000}{3.6} = 278\ \frac{m}{s}$$



y-dir. : $y = v_{y_0}t + \frac{1}{2}gt^2$

$$800 = 0 + \frac{1}{2}(9.81)t^2, \quad t = 12.77\ s$$

x-dir. : $x = v_{x_0}t + \frac{1}{2}a_x t^2$

$$= 278(12.77) + \frac{1}{2}\left(\frac{9.81}{2}\right)(12.77)^2$$

$$= 3950\ m$$

$$\theta = \tan^{-1}\frac{800}{3950} = \underline{11.46^\circ}$$