國立東華大學
NATIONAL DONG HWA UNIVERSITY

Department of Physics
PHYS10400, Class year 98

General Physics I
Midterm exam 1 solution

1.

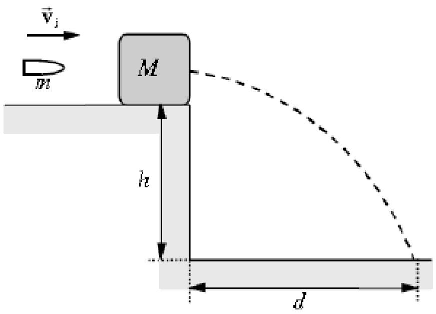


FIG. P9.53

Using conservation of momentum from just before to just after the impact of the bullet with the block:

$$mv_i = (M+m)v_f$$

or

$$v_i = \left(\frac{M+m}{m}\right)v_f \qquad (1)$$

The speed of the block and embedded bullet just after impact may be found using kinematic equations:

$$d = v_f t \quad \text{and} \quad h = \frac{1}{2}gt^2$$

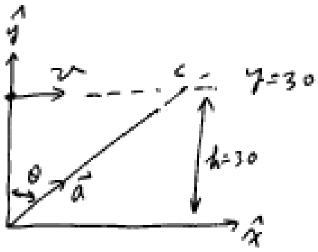
Thus,

$$t = \sqrt{\frac{2h}{g}} \quad \text{and} \quad v_f = \frac{d}{t} = d\sqrt{\frac{g}{2h}} = \sqrt{\frac{gd^2}{2h}}$$

Substituting into (1) from above gives $v_i = \boxed{\left(\frac{M+m}{m}\right)\sqrt{\frac{gd^2}{2h}}}$.

2.

Let the two particle meet @ point C. A moves with a constant velocity $\vec{v} = 3.0\,m/s$. B moves with an acceleration $\vec{a} = 0.4\,m/s$ and makes an angle θ with the positive y axis.



$$\sin\theta = \frac{\overline{AC}}{\overline{BC}} = \frac{vT}{\frac{1}{2}aT^2} \quad —\ (1)$$

$$\tan\theta = \frac{vT}{h} \quad —\ (2)$$

$$(1)\times(2) \quad \frac{\sin^2\theta}{\cos\theta} = \frac{1-\cos^2\theta}{\cos\theta} = \frac{2v^2}{ah} = \frac{2\cdot(3.0)^2}{0.4\times 30} = 1.5$$

$$\therefore\ 1-\cos^2\theta = 1.5\cos\theta \ \rightarrow\ \cos\theta = \frac{-1.5 \pm\sqrt{(1.5)^2+4}}{2} \ (\text{only positive})$$

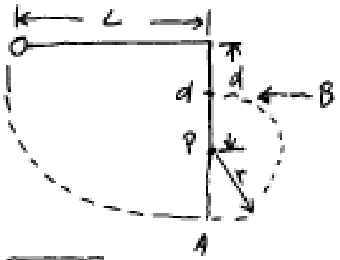
$$\theta = \cos^{-1}\left(\frac{-1.5+\sqrt{(1.5)^2+4}}{2}\right) =$$

$$= 60^\circ$$

3.

As shown in the figure

(a) When the ~~peg~~ ball reaches point A all the gravitational potential turns into it kinetic energy according to the conservation of energy



$mgL = \frac{1}{2} m V_A^2 \rightarrow V_A = \sqrt{2gL} = \sqrt{2\times9.8\times1.2} = 4.8 \ \text{m/sec}$ — (a)

(b) When the ~~peg~~ ball reaches point B

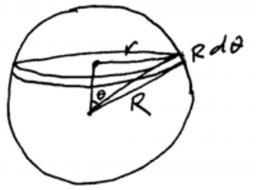
$E = mg y_B + \frac{1}{2} m V_B^2 = mgL$ But $y_B = 2(L-d)$

$\rightarrow mg\,2(L-d) + \frac{1}{2} m V_B^2 = mgL$

$\therefore V_B = \sqrt{2g(2d-L)} = \sqrt{2\times9.8\times(2\times0.75-1.20)} = 2.4 \ \text{m/sec}$ — (b)

4.

$$I = \int_0^{\pi} r^2\, dm$$



$$= \int_0^{\pi} R^2 \sin^2\theta \cdot 2\pi R^2 \sin\theta\, d\theta$$

$$= 2\pi R^4 \int_0^{\pi} \sin^2\theta \sin\theta\, d\theta$$

$$= 2\pi R^4 \int_{+1}^{-1} (1-\cos^2\theta)\, d(-\cos\theta)$$

$$= 2\pi R^4 \int_{-1}^{+1} (1-\cos^2\theta)\, d(\cos\theta)$$

$$= 2\pi R^4 \left[x - \frac{1}{3}x^3 \right]_{-1}^{1}$$

$$= 2\pi R^4 \cdot \frac{4}{3}$$

$$= \frac{8}{3}\pi R^4 = \frac{2}{3} M R^2$$

$r = R\sin\theta$

$dm = 2\pi r\, R\, d\theta$

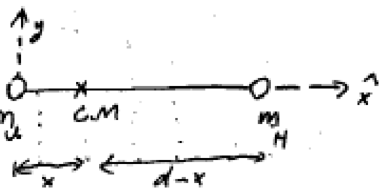
$= 2\pi R\sin\theta\, R\, d\theta$

$= 2\pi R^2 \sin\theta\, d\theta$

$M = 4\pi R^2$

5.

As shown in the figure to the right. first we find the center of mass



$m_{Cl}\, x = m_H(d-x)$.

$x = \frac{m_H}{m_{Cl}+m_H}\, d$.

$$I = \sum_i m r_i^2 = m_H (d-x)^2 + m_{Cl} x^2$$

$$= d^2 \frac{m_H m_{Cl}}{m_{Cl}+m_H} = 1.27\times10^{-10}\ \frac{(1.01\,u)(35.0\,u)}{35.0\,u + 1.01\,u} = 1.58\times10^{-20}\ (u\,m$$

6.

(a) The force acts on a specific displacement at a potential is $F = -\frac{dU(r)}{dr}$. This is also the slope of the potential at the discussed displacement. Compare these two potentials, we can see that the Morse potential has a smaller slope at all points when $r > r_e$, so you need smaller force to pull this molecule apart as compared to the harmonic potential.

(b) When the two atoms are separated at a very large distance, i.e. dissociated at the Morse potential, the slope is zero; so you do not need force to pull them further apart, F=0.