# Physics C: Mechanics Final Exam

Michael Brodskiy
Instructor: Mrs. Morse

December 16, 2020

Problem One:

---

$$\begin{aligned} \frac{1}{2}kx^2 &= mgh \\ h &= \frac{kx^2}{2mg} \end{aligned} \tag{1}$$

$$\begin{aligned} h(60) &\approx .6[\text{m}] \\ h(10) &\approx .1[\text{m}] \\ \frac{.6-.1}{60-10} &= .01[\text{kg m}] \end{aligned} \tag{2}$$

$$h = \frac{1}{100m} \tag{3}$$

$$\begin{aligned} \frac{1}{100} &= \frac{kx^2}{2g} \\ \frac{1}{5} &= kx^2 \\ x^2 = .05^2 &= .0025[\text{m}^2] \\ k = \frac{.2}{.0025} &= 80\left[\frac{\text{N}}{\text{m}}\right] \end{aligned} \tag{4}$$

---

Problem Two:

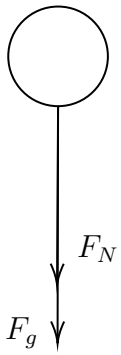


Figure 1: Free Body Diagram at point B

$$\begin{aligned} F_g &= \frac{mv^2}{r} \\ v^2 &= gr \\ v &= \sqrt{gr} \\ v &= 4.47 \left[\frac{\text{m}}{\text{s}}\right] \end{aligned} \tag{5}$$

$$\begin{aligned} mgh_o + \frac{1}{2}mv_o^2 &= \frac{1}{2}mv_f^2 \\ KE_o &= \frac{1}{2}mv_f^2 - mgh_o + mgh_f \\ .5 \cdot .05 \cdot (4.47)^2 - .05 \cdot 10 \cdot 3.6 + .05 \cdot 10 \cdot 4 &= .7[\text{J}] \end{aligned} \tag{6}$$

$$\begin{aligned} E_{total} &= \frac{1}{2}mv^2 + mgh \\ .5 \cdot .05 \cdot (4.47)^2 + .05 \cdot 10 \cdot 4 &= 2.5\,[\text{J}] \\ kx^2 &= 5 \\ x &= \sqrt{\frac{5}{200}} \\ x &= .16\,[\text{m}] \end{aligned} \tag{7}$$

$$\begin{aligned} mgh + \frac{1}{2}mv^2 &= 2.5 \\ mv^2 &= 5 - 2mgh \\ v &= \sqrt{\frac{5 - 2mgh}{m}} \\ &= 7.75 \left[\frac{\text{m}}{\text{s}}\right] \end{aligned} \tag{8}$$

Problem Three:

---

$$\begin{aligned} \Delta x &= 3t \\ 5 &= \frac{1}{2}gt^2 \\ t &= 1[\mathrm{s}] \\ \Delta x &= 3(1) = 3[\mathrm{m}] \end{aligned} \tag{9}$$

$$\begin{aligned} v_x &= 3\left[\frac{\mathrm{m}}{\mathrm{s}}\right] \\ v_y &= 10(1) = 10\left[\frac{\mathrm{m}}{\mathrm{s}}\right] \\ v_t &= \sqrt{3^2 + 10^2} \\ v_t &= 10.44\left[\frac{\mathrm{m}}{\mathrm{s}}\right] \end{aligned} \tag{10}$$

$$\begin{aligned} m_1v_1 + m_2v_2 &= (m_1 + m_2)v_f \\ 15 \cdot 3 &= (60)v_f \\ v_f &= .75\left[\frac{\mathrm{m}}{\mathrm{s}}\right] \end{aligned} \tag{11}$$

$$\begin{aligned} .5 \cdot 60 \cdot .75^2 &= \mu F_N \cdot 7 \\ F_N &= 600[\mathrm{N}] \\ \mu &= \frac{.5 \cdot 60 \cdot .75^2}{600 \cdot 7} \\ &= .004 \end{aligned} \tag{12}$$

---

Problem Four:

---

Free Body Diagrams on next page

Situation One:

$$\begin{aligned} F_{N_{10}} &= 100[\mathrm{N}] \\ F_f &= 30[\mathrm{N}] \\ F_T - F_f &= m_{10}a \\ F_T &= F_f + m_{10}a \\ F_g - F_T &= m_5 a \\ F_g - F_f &= 15a \\ a = \frac{20}{15} &= 1.33 \left[\frac{\mathrm{m}}{\mathrm{s}^2}\right] \end{aligned} \tag{13}$$

Situation Two:

$$\begin{aligned} F_{N_{10}} &= 100[\mathrm{N}] \\ F_f &= 30[\mathrm{N}] \\ F_T - F_f &= ma \\ F_T &= F_f + ma \\ F_a - F_f &= ma \\ F_a - F_f &= 10a \\ a = \frac{20}{10} &= 2 \left[\frac{\mathrm{m}}{\mathrm{s}^2}\right] \end{aligned} \tag{14}$$

---

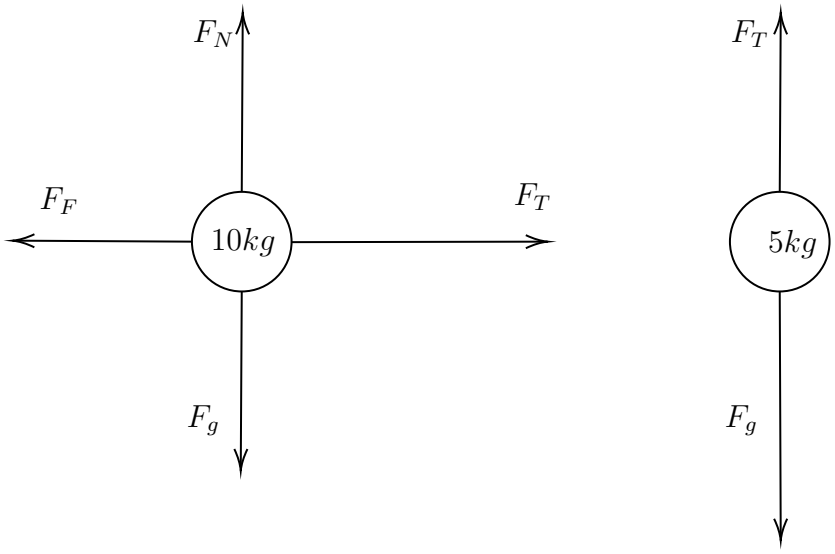


Figure 2: Situation 1

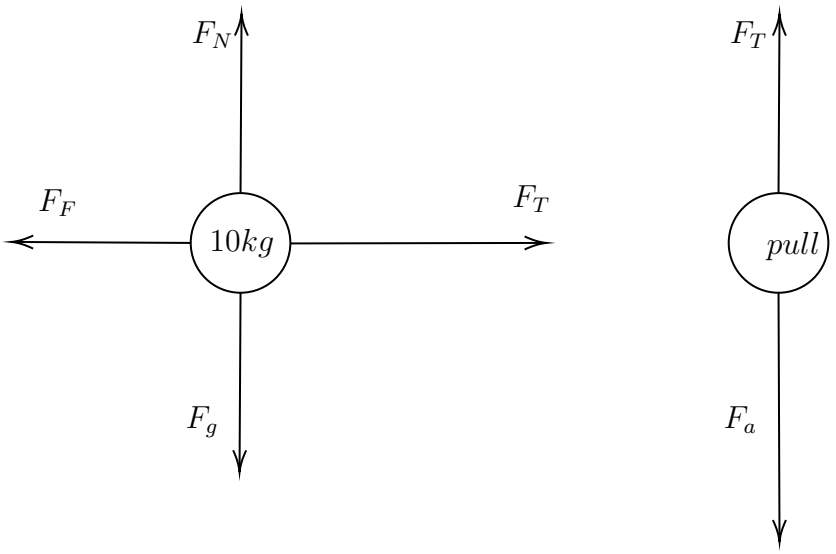


Figure 3: Situation 2

Problem Five:

---

Free Body Diagrams on next page

$$\begin{aligned}\int_0^6 100 - 10x\,dx &= 100x - 5x^2\Big|_0^6 \\ &= 420[\text{J}]\end{aligned} \tag{15}$$

$$\begin{aligned}420 &= \frac{1}{2}mv^2 + mgh \\ 420 - 2.8 \cdot 10 \cdot 6\sin(60^\circ) &= \frac{1}{2}mv^2 \\ v &= \sqrt{\frac{2(420 - 2.8 \cdot 10 \cdot 6\sin(60^\circ))}{2.8}} \\ &= 14\left[\frac{\text{m}}{\text{s}}\right]\end{aligned} \tag{16}$$

$$\begin{aligned}v_x &= 7\left[\frac{\text{m}}{\text{s}}\right] \\ v_y &= 7\sqrt{3}\left[\frac{\text{m}}{\text{s}}\right] \\ t &= \frac{7\sqrt{3}}{10} = 1.21[\text{s}] \\ t_{total} &= 2.42[\text{s}] \\ \Delta x &= 2.42 \cdot 7 \\ \Delta x &= 17[\text{m}]\end{aligned} \tag{17}$$

---

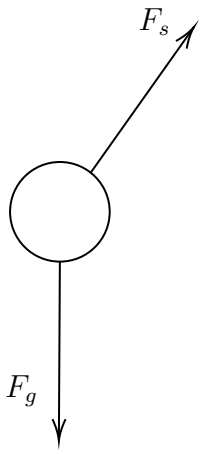


Figure 4: Free Body Diagram for Doll