Problem 1.

A 1.5 kg textbook slides along the horizontal surface of a table. The initial speed of the textbook is 2.0 m/s. It slides for a distance of 0.8 m, until it comes to rest (there is friction between the book and the table).

a) What is the initial kinetic energy of the book?

b) What is the total (net) work done on the book?

c) What is the work done by gravity?

d) What is the work done by friction?

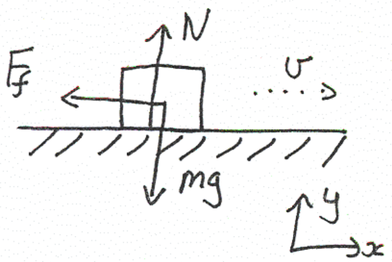
e) What is the coefficient of kinetic friction between the book and the table?

a) $KE_i = \frac{1}{2}mv^2 = \frac{1}{2}(1.5\,kg)(2.0\,m/s)^2 = \boxed{3.0\,J}$

b) $KE_f = 0 \quad \therefore \quad W_{net} = \Delta KE = KE_f - KE_i = 0 - 3J = \boxed{-3.0\,J}$

c) $W_{gravity} = (mg)d\cos 90° = 0$

d)



neither N nor mg do any work $(\theta = 90°)$ $\therefore$ $W_{net} = W_{friction}$

$W_{friction} = \boxed{-3.0\,J}$

e) $\sum \vec{F} = m\vec{a} \rightarrow y: \; N - mg = 0$

$\therefore N = mg$

$F_f = \mu_K N = \mu_K mg$

$W_{friction} = F_f \cdot d \cdot \cos(180°) = -\mu_K mgd$

$\therefore \mu_K = -\frac{W_{friction}}{mgd} = -\frac{(-3\,J)}{(1.5\,Kg)(9.8\frac{m}{s^2})(0.8\,m)}$

$= \boxed{0.255}$

Problem 2.

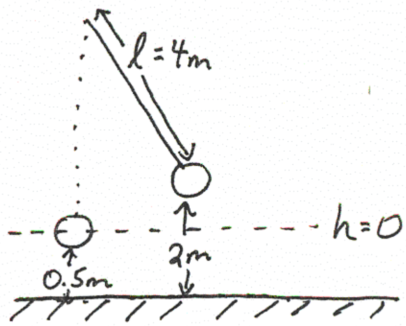
In the "nose-basher" demonstration, Professor Armstrong used a pendulum consisting of an iron ball which is attached via a cable to the ceiling. The ball starts off at rest, and is initially at a height of 2.0 m above the ground. At the bottom of its swing the ball is at a height of 0.5 m above the ground. The cable is 4.0 m long.

a) What is the speed of the iron ball at the bottom of its swing?

b) What is the angular velocity of the ball at this instant?

c) What is the centripetal acceleration of the ball at this instant? Give the magnitude and direction.

a) Pendulum: energy conserved (ignoring any air resistance)



$KE_i + PE_i = KE_f + PE_f$

$KE_i = 0$

choose $h=0$ @ bottom of swing

$\therefore PE_i = mgh \qquad h = 2.0 - 0.5 = 1.5m$

$$KE_f = \frac{1}{2}mv_f^2 = mgh \quad \therefore v_f = \sqrt{2gh} = \sqrt{2(9.8\frac{m}{s^2})(1.5m)}$$

$$= \boxed{5.42\ m/s}$$

b) $v = R\omega \qquad \omega = \frac{v}{R} = \frac{5.42\ m/s}{4.0m} = \boxed{1.36\ rad/s}$

c) $a_c = \frac{v^2}{R} = \frac{(5.42\ m/s)^2}{4.0m} = \boxed{7.35\ m/s^2}$

Direction = $\boxed{\text{upwards}}$

(centripetal = "center-pointing")

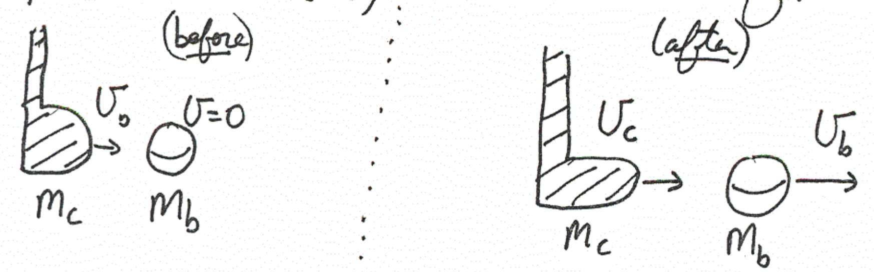
Problem 3.

A 200 gram golf club is travelling at 55 m/s just before it strikes a 46 gram golf ball, which is initially at rest. Just after the collision the golf club is travelling in the same direction as before, but at a speed of 40 m/s.

a) What is the speed of the golf ball just after the collision?

b) Show that this is an inelastic collision.

a) Collision (1D) → conservation of momentum



$p_i = p_f$

$$m_c v_0 + 0 = m_c v_c + m_b v_b$$

$$m_c(v_0 - v_c) = m_b v_b \quad \therefore \quad v_b = \frac{m_c(v_0 - v_c)}{m_b}$$

$$= \frac{200\,g\,(55\,m/s - 40\,m/s)}{46\,g}$$

$$= \boxed{65.2\ m/s}$$

b) $KE_i = KE_f$? (if so, elastic, otherwise inelastic)

$$KE_i = \frac{1}{2} m_c v_0^2 = \frac{1}{2}(0.2\,Kg)(55\,m/s)^2 = \boxed{302\ J}$$

$$KE_f = \frac{1}{2} m_c v_c^2 + \frac{1}{2} m_b v_b^2 = \frac{1}{2}(0.2\,Kg)(40\,m/s)^2 + \frac{1}{2}(0.046\,Kg)(65.2\,m/s)^2$$

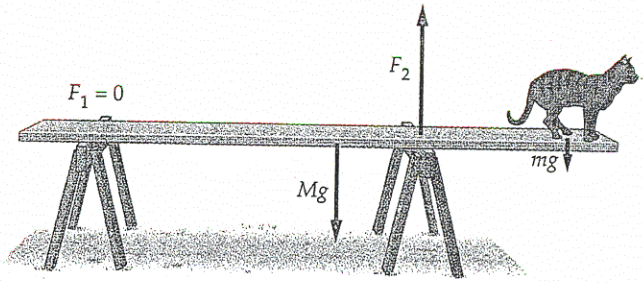
$$= 160\,J + 98\,J$$

$$= \boxed{258\ J}$$

$\therefore KE_f < KE_i$

$\therefore$ inelastic

Problem 4.



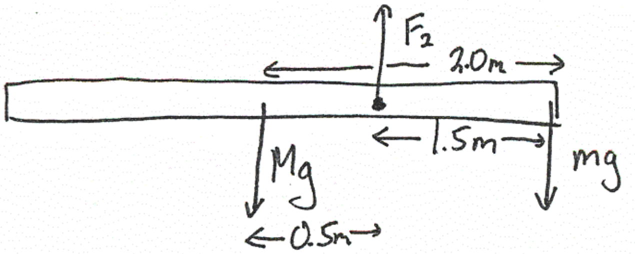
A cat walks along a uniform board which is 4.0 m long and has a mass of 7.0 kg. The plank is supported by two sawhorses, one 0.4 m from the left end of the board and the other 1.5 m from the right end of the board. When the cat reaches the extreme right end, the board begins to tip (this means that the left sawhorse exerts no force on the board at this time).

a) Consider the right sawhorse as the pivot point. What is the torque about this point due to the weight of the plank? Give both the magnitude and direction.

b) What is the mass of the cat?

c) What is the force that the right sawhorse exerts on the board?

a)



uniform board ∴ center of gravity is halfway along board.

$\tau = rF\sin\theta = (0.5\,m)(7.0\,Kg)(9.8\,m/s^2)\sin 90° = $ **34.3 N·m**

direction : **CCW** ↺

b) $\tau_{net} = 0$ F_2 causes no torque

∴ $\tau_{cat} = 34.3\,Nm$ CW

$\tau_{cat} = mg(1.5\,m)$ ∴ $m = \dfrac{34.3\,Nm}{(9.8\,m/s^2)(1.5\,m)} = $ **2.33 Kg**

c) $\vec{F}_{net} = 0$ y: $Mg + mg - F_2 = 0$

$F_2 = (M+m)g$

$= (7.0\,Kg + 2.33\,Kg)(9.8\,m/s^2)$

$=$ **91.5 N**