Ch 6 and Ch 7 Problem Review

Mahapatra
Revisiting the work energy theorem

The work energy theorem says the total work is equal to the change in KE

\[ W_{net} = KE_2 - KE_1 \]

On the other hand, we have seen that the work due to gravity ONLY DEPENDS ON THE INITIAL AND FINAL POINT OF THEIR PATH, NOT ON THE ACTUAL PATH. These type of forces (of which gravity is one) are called conservative forces. Let’s break the total work done into two parts, the one done by the conservative forces and the ones done by non-conservative forces (e.g. friction)

\[ W_{conserv} + W_{non-conserv} = KE_2 - KE_1 \]

\[ -UE_2 + UE_1 + W_{non-conserv} = KE_2 - KE_1 \]

\[ W_{non-conserv} = E_2 - E_1 \quad \text{where} \quad E = KE + UE \]

If the work done by the non-conservative forces is zero then the total energy is conserved. This is a very powerful tool!!
Problem 7.55 Pulley problem

What is the speed of the larger block before it strikes the ground?

TWO CHOICES: CH 4-5 style or CH 6-7 style

Because there is no friction then energy is conserved

\[ E_A = E_B \]

\[ \frac{1}{2} m_1 v_{A1}^2 + m_1 g y_{A1} + \frac{1}{2} m_2 v_{A2}^2 + m_2 g y_{A2} = \frac{1}{2} m_1 v_{B1}^2 + m_1 g y_{B1} + \frac{1}{2} m_2 v_{B2}^2 + m_2 g y_{B2} \]

\[ 0 + 0 + 0 + (12 \text{Kg})(9.8 \text{m/s}^2)(2.00 \text{m}) = \frac{1}{2}(4 \text{Kg}) v^2 + (4 \text{Kg})(9.8 \text{m/s}^2)(2.00 \text{m}) + \frac{1}{2}(12 \text{Kg}) v^2 + 0 \]

\[ v = 4.43 \frac{m}{s} \]

Now let’s do it the longish way (Ch 4-5)

For \( m_1 \) Newton’s 2nd law reads  
\[ y : \quad -m_1 g + T = m_1 a \quad \Rightarrow T = m_1 a + m_1 g \]

For \( m_2 \) Newton’s 2nd law reads  
\[ y : \quad +m_2 g - T = m_2 a \]

\[ +m_2 g - (m_1 a + m_1 g) = m_2 a \]

\[ +m_2 g - m_1 a - m_1 g = m_2 a \]

\[ (m_2 - m_1)g = (m_2 + m_1)a \]

\[ \frac{(m_2 - m_1)}{(m_2 + m_1)} g = a \]

What if I had asked for the time? Would I have a choice?

Then we use kinematic to solve for \( v \) (Ch 1-3)

\[ y - y_0 = -h \]
\[ v_y = ? \]
\[ v_{y0} = 0 \]
\[ a_y = \left( \frac{m_2 - m_1}{m_1 + m_2} \right) g \]
\[ t = \]

\[ v_y = \sqrt{2 \left( \frac{m_2 - m_1}{m_1 + m_2} \right) gh} = 4.43 \frac{m}{s} \]
Problem 7.46: Energy + circular motion

A car in an amusement park ride rolls without friction around the track shown in the figure. It starts from rest at point A at a height h above the bottom of the loop. Treat the car as a particle.

(a) What is the minimum value of h (in terms of R) such that the car moves around the loop without falling off at the top (point B)?

(b) If the car starts at height h = 4.00 R and the radius is R = 20.0 m, compute the radial acceleration of the passengers when the car is at point C, which is at the end of a horizontal diameter.

What is the minimum velocity so at B we are going around a CIRCLE? You will feel like you are flying and not touching the track?

Now we know the velocity (or KE) we need at B so we can use conservation of energy (remember $F_N$ does no work so $W_{\text{other}} = 0$) to get it

\[
E_A = E_B
\]

\[
\frac{1}{2} m v_A^2 + mgy_A = \frac{1}{2} m v_B^2 + mgy_B
\]

\[
0 + mgh = \frac{1}{2} mgR + mg2R
\]

\[
h = \frac{5}{2} R
\]
Problem 7.46: Energy + circular motion

A car in an amusement park ride rolls without friction around the track shown in the figure. It starts from rest at point A at a height $h$ above the bottom of the loop. Treat the car as a particle.

(a) What is the minimum value of $h$ (in terms of $R$) such that the car moves around the loop without falling off at the top (point B)?

(b) If the car starts at height $h = 4.00 \text{ R}$ and the radius is $R = 20.0 \text{ m}$, compute the radial acceleration of the passengers when the car is at point C, which is at the end of a horizontal diameter.

The radial acceleration is $v^2/R$ so we need $v$ at C. We can use conservation of energy (remember $F_N$ does no work so $W_{\text{other}} = 0$) to get it:

\[
E_A = E_C
\]

\[
\frac{1}{2} m v_A^2 + mgy_A = \frac{1}{2} m v_C^2 + mgy_C
\]

\[
0 + mg4R = \frac{1}{2} m v^2 + mgR
\]

\[
v^2 = 3gR \quad \Rightarrow \quad a_r = \frac{v^2}{R} = 3g
\]
Problem 7.63 Conservation of energy and circular motion

A skier starts at the top of a very large, frictionless snowball, with a very small initial speed, and skis straight down the side (the figure). At what point does she lose contact with the snowball and fly off at a tangent?

Similar to the roller coaster from A to B use conservation and at B use $F_N=0$ when it flies off.

\[ E_A = E_B \]

\[ \frac{1}{2} m v_A^2 + mgy_A = \frac{1}{2} m v_B^2 + mgy_B \]

\[ 0 + mgR = \frac{1}{2} m v^2 + mgR \cos \alpha \]

\[ v^2 = 2Rg(1 - \cos \alpha) \]

\[ r: \quad mg \cos \alpha - F_N = m \frac{v^2}{R} \quad \Rightarrow \quad mg \cos \alpha - 0 = m2g(1 - \cos \alpha) \]

\[ \tan: \quad mg \sin \alpha = ma_{\text{tan}} \quad \cos \alpha = \frac{2}{3} \Rightarrow 48^o \]
Problem 6.76

• Proton of mass m moves with velocity v1 towards a uranium nucleus at a distance L1 away. The proton is repelled by a force or magnitude F = alpha/x^2, where x is the separation between the 2 objects. A) What is the speed of the proton when it is a distance L2 away. B) At what distance does the proton comes to a stop and then return back and moves away? C) What is speed when it goes back to a distance L3 away?
Problem 7.66

• A truck with mass m has brake failure while going down a road at an angle alpha. After going down a distance L, the truck heads up a ramp at an angle beta with friction mu. What is the distance the truck moves up the ramp?
Problem 7.68

• A sled with rider having a total mass M travels over a perfectly smooth hill of height H. How far away do they land from the foot of the cliff.