**Review 3**

**Review for the CQZ#3**

**Centripetal Motion and Energy Conservation**

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**Examples for Energy Conservation**

- Kinetic Energy changes
- Gravitational Potential Energy
- Elastic Potential Energy

Total Mechanical Energy = Const.

\[ K_f - K_i = W = mg - |W_{friction}| \]

\[ E_f - E_i = K_f - (K_i + mg) = -|W_{friction}| = f_k d \cdot \cos 180° = f_k d = mg \mu \cdot d \cdot \cos 18° \]

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**Centripetal Force is a combination of:**

- Gravitational Force: down to the ground
- Tension Force: along the string
- Normal Force: perpendicular to the support
- Static Friction Force maximum value: \( F_{fr}^{max} = \mu_{st} N \)

**Centripetal Force and Tension Force:**

\[ m a_c = \frac{mv^2}{R} = \Sigma (\text{all forces along the direction towards the center}) \]
Problems:

A 10.0-kg crate slides along a horizontal frictionless surface at a constant speed of 4.0 m/s. The crate then slides down a frictionless incline and across a second rough horizontal surface as shown in the figure.

\[ K_i = \frac{m \cdot v_i^2}{2} \]
\[ U_i = m \cdot g \cdot \Delta y \]
\[ K_f = K_i + \phi = \frac{m \cdot v_f^2}{2} \]
\[ v_f = \sqrt{\frac{2}{m} \cdot \frac{m \cdot v_i^2 + m \cdot g \cdot \Delta y}{2} + \frac{2}{g} \cdot \Delta y} = \sqrt{\left(\frac{2}{m} \cdot \frac{2}{g}\right)^2 + \frac{2}{g} \cdot \Delta y} \]

What minimum coefficient of kinetic friction \( \mu_k \) is required to bring the crate to a stop over a distance of 10 m along the lower surface?

\[ K_f - K_i = W_{\text{friction}} = -mg\mu_k \]
\[ 0 - \frac{1}{2}mv^2 = -mg\mu_k \]
\[ \frac{1}{2}mv^2 = mg\mu_k d \]
\[ \mu_k = v^2/2gd = \frac{(8.6m/s)^2}{2 \cdot 10m/s^2 \cdot 10m} \approx 0.37 \]

Example of the 3rd Common Exam

Problem 1: What is the work done by a force \( F = (2 \text{N}) \hat{x} + (-4 \text{N}) \hat{y} \) that causes a displacement \( \Delta \mathbf{d} = (-3 \text{m}) \hat{x} + (-4 \text{m}) \hat{y} \)?

A) 2 J
B) 14 J
C) -14 J
D) 2 J
E) 16 J

Problem 2: A man pushes a 2-kg block 3 m along a frictionless incline at an angle of 20° with the horizontal at constant speed. What is the work done by his force?

A) 0 J
B) 98 J
C) 84 J
D) 92 J
E) 100 J

Problem 3: Starting from rest, it takes 8.00 s to lower with constant acceleration an 800-kg coach from a 16.0-m high rooftop to a building all the way to the ground with a single vertical rope tied to its body. What is the work done by the tension in the rope?

A) 1.57 kJ
B) -1.28 kJ
C) -1.25 kJ
D) -12.5 kJ
E) -11.9 kJ

Problem 4: A 10 kg mass is attached to one end of a 50.0 cm long unstretched spring. When the other end of the spring is attached to the ceiling the mass reaches a stable stationary position as shown in the adjacent diagram. What is the spring constant of the spring?

A) 490 N/m
B) 340 N/m
C) 240 N/m
D) 140 N/m
E) 196 N/m

Problem 5: A dog must apply its full power of 100 W in order to move a 5-kg sled by a distance of 10 m in 4 s. What average force does the dog exert on the sled?

A) 99 N
B) 250 N
C) 21 N
D) 40 N
E) 200 W

Problem 6: A bicyclist is travelling on a horizontal track at a speed of 20.0 m/s as he approaches the bottom of a hill. He decides to count up the hill and stop when reaching the top. Determine the vertical height of the hill.

A) 28.5 m
B) 37.0 m
C) 11.2 m
D) 40.8 m
E) 50.4 m

\[ \frac{mv^2}{2} = mg \Delta y \]
\[ \Delta y = \frac{v^2}{2g} = \frac{20^2 (m/s)^2}{2 \cdot 9.8 \text{ m/s}^2} = 20.4 \text{ m} \]
Problem 7. A mass \( m = 2.5 \text{ kg} \) is sliding left along a frictionless table with initial speed \( v \). It strikes a coiled spring that has a force constant \( k = 300 \text{ N/m} \) and compresses it a distance 3.0 cm before coming to a momentary rest. The initial speed \( v \) of the block was
\[
\begin{align*}
\text{A)} & \ 8.71 \text{ m/s} \\
\text{B)} & \ 5.0 \text{ m/s} \\
\text{C)} & \ 4 \text{ m/s} \\
\text{D)} & \ 5.50 \text{ m/s} \\
\text{E)} & \ 1.7 \text{ m/s}
\end{align*}
\]

Find \( v, T, \) and \( a \).

\[
\begin{align*}
\sin \theta &= \frac{R}{L} = 0.4; \quad \tan \theta &= \frac{(R/L)^2}{1-(R/L)^2} = 0.44 \\
X: \quad ma &= T \sin \theta \\
Y: \quad ma &= 0 = -mg + T \cos \theta
\end{align*}
\]
What if the road is banked? 

\[ \text{v}_{\text{max}} = 50 \text{ m/s}; \quad \mu_{st} = 0.5 \]

Angle 10° 

Find \( R_{\text{min}} \)

\[ \frac{m v^2}{R} = f_{st} \quad ; \quad f_{st} = \mu_{s} N = \mu_{s} mg \]

\[ \frac{m v^2}{R} = m \frac{v^2}{R} = mg \quad ; \quad R = \frac{v^2}{\mu_{s} g} = \frac{50 \cdot 50}{0.5 \cdot 9.8} = 510 \text{ m} \]
(b) [1 point] If the curve is banked rather than flat, does the minimum radius at which the car can turn without skidding at 50 m/s increase or decrease compared to the case of a flat curve? **IN ORDER TO RECEIVE CREDIT, YOU MUST JUSTIFY YOUR ANSWER using a diagram and a brief explanation.**

\[ b) \]

\[ R \]

\[ mg \]

\[ R \text{ will decrease} \]

\[ \text{since} \quad N \cdot \sin \Theta \]

\[ \text{will contribute to the} \]

\[ \text{centripetal force} \]

\[ ma^c = f_t \cdot \cos\Theta + N \sin\Theta \]

\[ ma^c = N \cdot \mu \cdot \cos\Theta + N \sin\Theta \]

\[ N = \frac{mg}{\cos\Theta} \]

\[ ma^c = N \cdot \left( \mu \cdot \cos\Theta + \tan\Theta \right) = mg \cdot \frac{\mu \cdot \cos\Theta + \tan\Theta}{\cos\Theta} = mg \left( \mu + \tan\Theta \right) \]

\[ \frac{mv^2}{R'} = mg \left( \mu + \tan\Theta \right) \]

\[ R' = \frac{V^2}{g (\mu + \tan\Theta)} < \frac{V^2}{g \mu} = R \implies R' < R \]