PHYS 101: General Physics KOÇ UNIVERSITY Fall Semester 2015

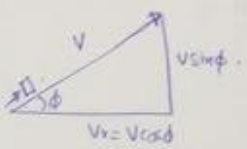
College of Arts and Sciences

Quiz - Ch.6

Closed book. No calculators are to be used for this quiz.

Name: Student ID: Signature:

A motorcyclist is riding at a constant speed v up a hill which has an inclination angle of ϕ. The power delivered by the engine of the motorcycle is mgv, where m is the mass of the motorcycle (plus the rider) and g is the gravitational acceleration. Find the power lost to frictional forces in terms of m, g, v, ϕ.



$$\frac{W_f}{t} = \frac{W_{done}}{t} - \frac{P.E.}{t}.$$

$$P_f = P_{given} - \frac{U}{t}$$

$$= mgv - mgv\sin\phi.$$

$$= mgv[1 - \sin\phi].$$

OR

$$W_{done} = \int_0^t mgv.\,d\tau = mgvt.$$

$$U = \int_0^t mgv\sin\phi.\,d\tau = mgv\sin\phi.t.$$

$$\Rightarrow W_f = mgvt - mgv\sin\phi.t.$$

$$P_f = mgv - mgv\sin\phi.$$

$$= mgv[1 - \sin\phi].$$

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A small block with a mass m is attached to a cord passing through a hole in a frictionless, horizontal surface. The block is originally revolving at a distance $r = r_1$ from the hole with a speed $v = v_1$. The cord is then slowly pulled from below, shortening the radius to r_2. Throughout the process, r and v change, but their product satisfies $rv = r_1 v_1$ at all times. Find the work done by the person pulling the cord.

$W_{done} = K_1 - K_2$

$= \frac{1}{2} m v_1^2 - \frac{1}{2} m v_2^2$. Here $v_2 = \frac{r_1 v_1}{r_2}$.

K_1 = kinetic energy at r_1.

$\because v_2 = \frac{r_1}{r_2} v_1$. K_2 = " " " r_2.

$= \frac{1}{2} m v_1^2 - \frac{1}{2} m \left(\frac{r_1}{r_2} v_1\right)^2$ with $r_1 v_1 = r_2 v_2$ given

$= \frac{1}{2} m v_1^2 \left[1 - \left(\frac{r_1}{r_2}\right)^2\right]$.

$$\boxed{W_{done} = \frac{1}{2} m v_1^2 \left[1 - \left(\frac{r_1}{r_2}\right)^2\right]}$$

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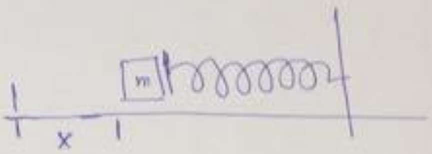
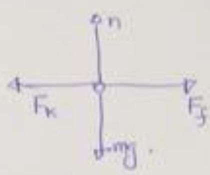
A textbook with mass m is forced against a horizontal and ideal spring with force constant k, compressing the spring a distance x. When released from this position, the book slides on a horizontal tabletop with a coefficient of kinetic friction μ_k and comes to rest after moving by a distance $x/2$ (that is, when the spring is still compressed by $x/2$). Find x in terms of m, k, μ_k, and the gravitational acceleration g.



$$W_{done} = K + U + W_f .$$

$$\frac{1}{2}kx^2 = 0 + \frac{1}{2}k\left[\frac{x}{2}\right]^2 + \int_0^{x/2} \mu_k mg \cdot dx$$



$$\Rightarrow \frac{1}{2}kx^2 = \frac{1}{2}k\frac{x^2}{4} + \mu_k mg\, x \Big|_0^{x/2} .$$

$$\frac{1}{\cancel{2}}kx^{\cancel{2}}\left[1 - \frac{1}{4}\right] = \mu_k mg \cdot \frac{\cancel{x}}{\cancel{2}}$$

K= kinetic Energy.

U= potential Energy.

W_f= lost in friction.

$$\Rightarrow \frac{3x}{4} = \frac{\mu_k \cdot mg}{k}$$

$$\boxed{x = \frac{4}{3}\frac{\mu_k mg}{k}.}$$

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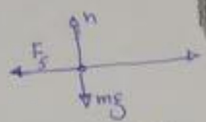
An object slides on a very large, horizontal ice ring with a variable coefficient of kinetic friction $\mu_k(x) = e^{-x/b}$, where x is the distance from the entrence. If the object enters the ring with speed v and moves on a straight line, what is the minimum value of v so that it never stops?

$$\mu_k(x) = e^{-x/b}.$$

$$K = \frac{1}{2} m v^2.$$



$$W_f = \int_0^x mg \cdot e^{-x/b} \cdot dx$$

$$= mg \cdot \frac{e^{-x/b}}{-1/b} = -mgb\, e^{-x/b} \Big|_0^x = +[mgb - mgb\, e^{-x/b}].$$

for object to never stop

$$K > W_f \qquad [K + W_f > 0; \quad v = 0]$$

$$\frac{1}{2} \cancel{m} v^2 > -\cancel{m} g b\, e^{-x/b} + mgb.$$

$$v^2 \geq -2gb\, e^{-x/b} + mgb. \qquad \text{at } x = \infty,$$

$$v > \sqrt{2gb\, e^{-x/b} + mgb}.$$

$$\boxed{\cancel{v > \sqrt{2gb}\, e^{-x/b}}}$$

$$\boxed{v = \sqrt{mgb}.} \to \text{Ans.}$$

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A car with mass m and moving at speed v enters an icy patch on the highway and starts skidding. The coefficient of kinetic friction between tires and the road decreases with the distance x from the beginning of the patch as $\mu_k(x) = b/(b+x)$. The car stops at $x = x_f$. Write down the work-energy theorem for the motion between $x = 0$ and $x = x_f$, expressing the work done by friction as an integral. (Gravitational acceleration is g.)

$$W_I = K_I + U_I + W_{fI} \quad [\text{initial}].$$
$$= \frac{1}{2}mv^2 + 0 + 0.$$

$$W_f = K_f + U_f + W_{fI} \quad [\text{final}]$$
$$= 0 + 0 + \int_0^{x_f} \mu_k \cdot mg \cdot dx = \int_0^{x_f} \frac{b}{b+x} \cdot mg \cdot dx = bmg \cdot \ln[x+b]\Big|_0^{x_f}$$

$\because \quad W_i = W_f.$

$$\Rightarrow \frac{1}{2}mv^2 = \cancel{\mu_k \cdot mg\, x}\Big|_0^{x_f}.$$
$$= bmg\,[\ln(x_f+b) - \ln(b)].$$
$$\frac{1}{2}\cancel{mv^2 = bmg} \ln\left[\frac{x_f+b}{b}\right].$$

$$\frac{1}{2}mv^2 = \int_0^{x_f} \frac{b}{b+x}\, mg.dx.$$
$$= bmg \ln\left[\frac{x_f+b}{b}\right].$$