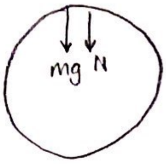
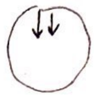
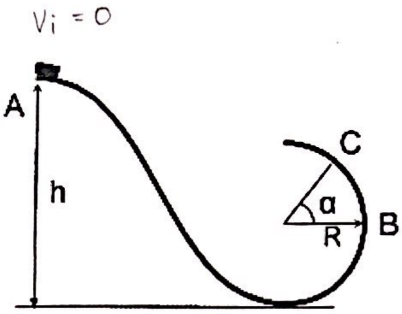




Problem 1



A small block, initially at rest at point A, slides down a curve leading to a half-circle of radius R without friction. (Express all answers in terms of R, α, h, g.)

a) Assuming h > R, what is the speed at point B?

$\underline{y|}\quad m a_T = -mg \qquad a_T = -g$

$\underline{x|}\quad \frac{mv^2}{R} = N$

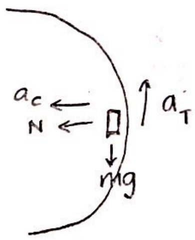
$v^2 = \frac{NR}{m}$

$E_f = E_i + \cancel{W^{NC}}$ no friction!

$\frac{1}{2}mv^2 + mgh = mgh$

$\frac{v^2}{2} + gR = gh$

$\boxed{v = \sqrt{2gh - 2gR}}$ ✓ +15

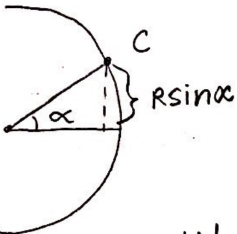


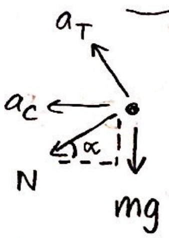
b) The block loses contact with the surface at point C, where the radius makes angle α with the horizontal. What is the height h of point A?

" loses contact " means $F_N = \varnothing$

$mgh = \frac{1}{2}mv^2 + mgh$

$gh = \frac{1}{2}v^2 + gh$





$\underline{y|}\quad 0 = -mg - N\sin\alpha$

$mg = -N\sin\alpha$

$N = \frac{-mg}{\sin\alpha}$

$\underline{x|}\quad \frac{mv^2}{R} = \cancel{N}\cancel{\cos}\alpha$ (mg sin)

$\frac{mv^2}{R} = \frac{-mg\cos\alpha}{\sin\alpha}$

$v = \sqrt{\frac{-Rg\cos\alpha}{\sin\alpha}}$

+11

$E_f = E_i + \cancel{W^{NC}}$

$\frac{1}{2}mv^2 + mgh = mgh$

$\frac{1}{2}m\left[\frac{-Rg\cos\alpha}{\sin\alpha}\right] + mg(R + R\sin\alpha) = mgh$

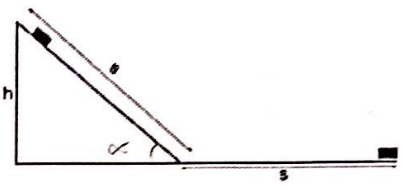
$\frac{-R\cos\alpha}{2\sin\alpha} + R + R\sin\alpha = h$

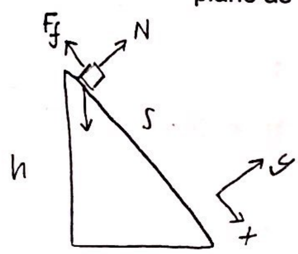
$h = \frac{-R\cos\alpha}{2\sin\alpha} + R(1 + \sin\alpha)$

$$\boxed{h = R\left(+ \frac{\overset{\sin}{\cancel{\cos}}\alpha}{2\cancel{\sin\alpha}} + 1 + \sin\alpha \right)}$$

Problem 2

A body with zero initial velocity slides along an inclined plane forming an angle α with the horizon, then continues moving over a horizontal plane, and then comes to rest. The friction coefficient is the same on the inlcined plane and on the horizontal surface. Find the coefficient of friction μ if the body covers the same distance S on the horizontal plane as on the inclined plane.





$y|$ $0 = -mg\cos\theta + N$

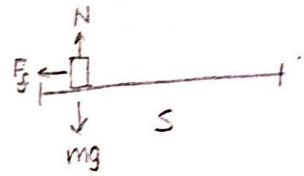
$N = mg\cos\theta$

$x|$ $ma = mg\sin\theta - F_f$

$ma = mg\sin\theta - \mu N$

$ma = mg\sin\theta - \mu mg\cos\theta$

$a = g\sin\theta - \mu g\cos\theta$



$x|$ $ma = -F_f$

$ma = -\mu mg$

$a = -\mu g$

$V_f^2 = V_i^2 + 2a\Delta x$

$V_f^2 = 0 + 2(g\sin\theta - \mu g\cos\theta)s$

$V_f^2 = V_i^2 + 2a\Delta x$

$0 = V_i^2 + 2(-\mu g)s$

$2sg(\sin\theta - \mu\cos\theta) = 2\mu sg$

$\sin\theta - \mu\cos\theta = \mu$

$\sin\theta = \mu + \mu\cos\theta$

$\sin\theta = \mu(1 + \cos\theta)$

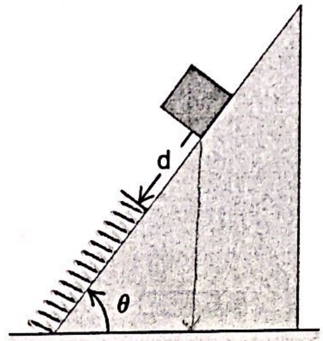
$$\boxed{\mu = \frac{\sin\theta}{1+\cos\theta}}$$

✓ +30

Problem 3

$V_i = 0$

A block of mass m=1 kg slides without friction down an inclined plane making angle θ=30° with the horizontal, lands on a spring with the spring constant k=10 N/m, and bounces back. The initial distance between the block and the end of the undeformed spring is d=1 m. Find the maximal speed the block will reach.

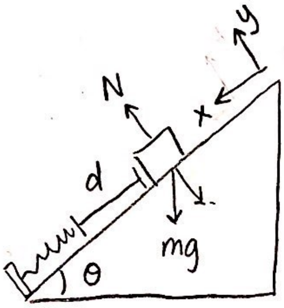


$\theta = 30°$ $\quad m = 1\ kg$

$k = 10\ N/m$

$V_{max} = ?$

- V_{max} will occur when spring is no longer compressed



$E_f = E_i + W^{NC}$ $\qquad W = Fd\cos\theta$

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 + Fd\cos\theta + mgh$ $\qquad W = mg\sin\theta\, d$

$\frac{1}{2}m\boxed{v^2} = \frac{1}{2}kx^2 + Fd\cos\theta + mg(d\sin\theta + x\sin\theta)$

$mv^2 = kx^2 + 2Fd\cos\theta + 2mg(d\sin\theta + x\sin\theta)$

$mv^2 = 10x^2 + 9.81 + 19.62(0.5 + \frac{x}{2})$

$V = 8.831\ m/s$

no friction!

$E_i + \cancel{W^{NC}} = E_f$

top of incline $\qquad$ bottom, spring fully compressed

$mg(d\sin\theta + x\sin\theta) = \frac{1}{2}kx^2$

$4.905 + 9.81\sin\theta x = 5x^2$

$0 = 5x^2 - 9.81\sin\theta x - 4.905$

$X = 1.596\ m$

immediately after losing contact w/ spring $\quad \boxed{\frac{1}{2}mv^2 = \frac{1}{2}kx^2}$ $\quad$ initial, when spring is fully compressed

$v^2 = 10(1.596)^2$

$\boxed{V = 5.047\ m/s}$

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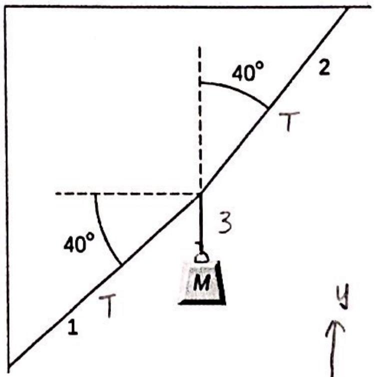
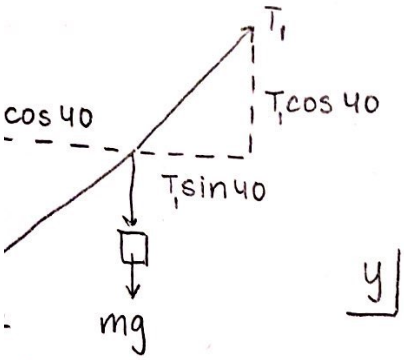
Problem 4

If mass M=10 kg is attached as shown in the figure, what is the tension in string 2?





$m = 10$ kg

y | $ma_y = T_1 \cos 40 - T_2 \sin 40 + mg$

$0 = T_1 \cos 40 - T_2 \sin 40 + mg$ x

+25

x | $0 = T_1 \sin 40 - T_2 \cos 40$ X

$T_1 = \dfrac{T_2 \cos 40}{\sin 40}$

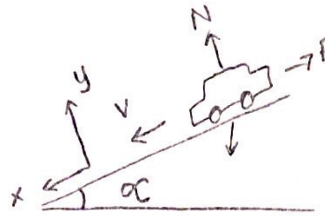
just mixed up sines + cosines

$0 = \dfrac{T_2 \cos^2 40}{\sin 40} - T_2 \sin 40 - mg$

$mg = T_2 \left(\dfrac{\cos^2 40}{\sin 40} - \sin 40 \right)$

$T_2 = \dfrac{mg}{\left(\dfrac{\cos^2 40}{\sin 40} - \sin 40 \right)} = 363.133$ N

$\boxed{363 \text{ N}}$



$m = M$

Problem 5

A car with mass M runs downhill with its engine turned off at a constant speed v. The road makes angle α with the horizontal.

a) Find the coefficient of friction.

$\mu = ?$

$\underline{y}|$ $0 = -mg\cos\alpha + N$

$N = mg\cos\alpha$

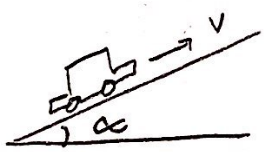
$\underline{x}|$ $0 = mg\sin\alpha - \mu N$

$0 = mg\sin\alpha - \mu mg\cos\alpha$

$\mu\cos\alpha = \sin\alpha$

$\boxed{\mu = \tan\alpha}$

b) What is the required power P to make this car run upward at the same angle with the same speed v?



$P = \vec{F} \cdot v$ or $P = \frac{W}{\Delta t}$

X

$\vec{a} = \emptyset$, so +3

$\cdot\ \vec{F}$ is $\emptyset$

$W = \Delta KE$

$W = \frac{1}{2}mv^2 - \frac{1}{2}mv^2$

v is const, so $W = \emptyset$

$\boxed{P = \emptyset \text{ W}}$

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