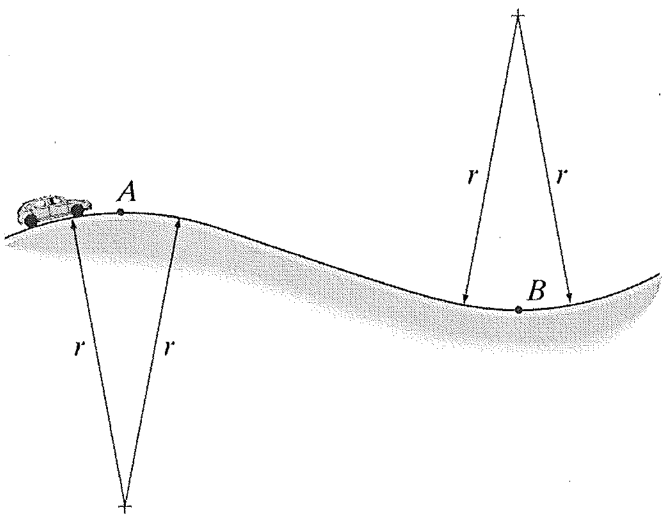
(1.) A car drives along a road with constant speed. If, as shown, the road can be approximated as parts of two equal radii circles, at which point does the driver's apparent weight have its largest value?



(a) Point A.	$\boxed{\text{(b) Point } B.}$
(c) Neither A nor B. The maximum occurs when the car is driving on a flat road.	
(d) Both A and B have the same maximum apparent weight.	
(e) It cannot be determined without knowing the speed of the car.	

AT A: $\uparrow \vec{n}$ $\downarrow \vec{w}$ $\downarrow \vec{a}_{rad}$

$$\sum F_y = ma_y \Rightarrow n - w = m(-a_{rad}) = -\frac{mv^2}{r}$$

$$\Rightarrow n = w - \frac{mv^2}{r} \Leftarrow n < w \text{ for any } v$$

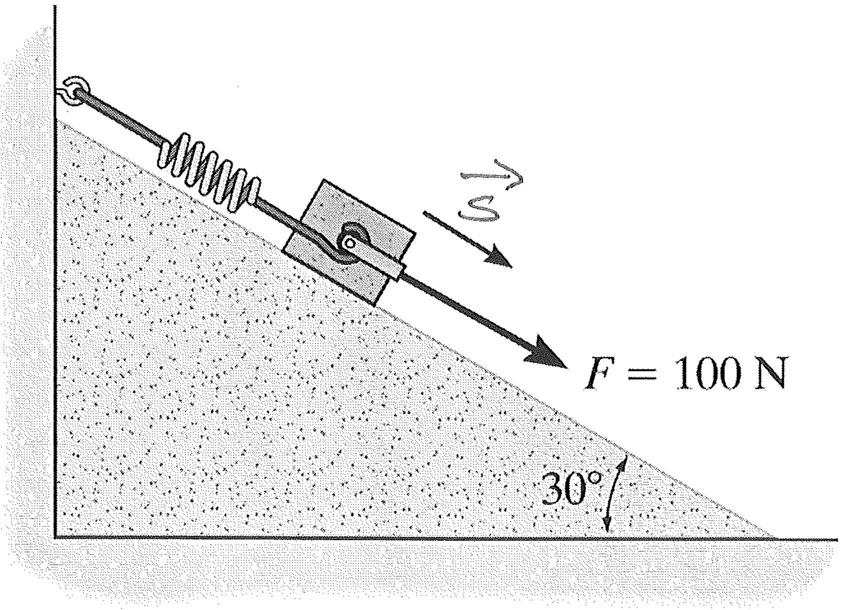
AT B: $\uparrow \vec{n}$ $\downarrow \vec{w}$ $\uparrow a_{rad}$

$$\therefore n - w = m(+a_{rad}) = \frac{mv^2}{r}$$

$$\Rightarrow n = w + \frac{mv^2}{r} \Leftarrow n > w \text{ for any } v$$

ON Flat ROAD: $a = 0$ so $n = w$

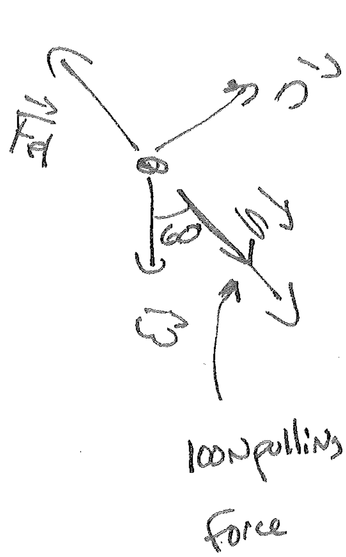
(2.) A 100-N force is applied to pull a mass, which is attached to a spring, down a frictionless 30° incline as shown. Which of the following forces does negative work on the mass?



(a) Gravity.
(b) The spring force.
(c) The pulling force.
(d) The normal force.
(e) All of these except for the normal.

Intuitively: Spring only force trying to slow MASS DOWN ⇒ Negative work.
Spring pulls BACK ON MASS since it's Being stretched

Mathy Version:

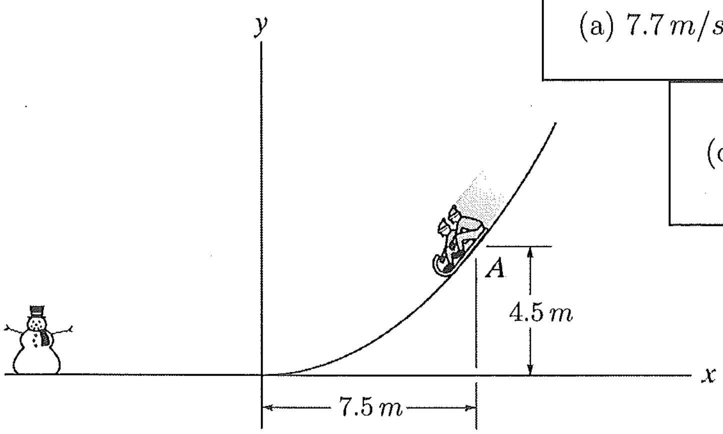


so $\phi = 60°$ for $\vec{\omega}$, 0° for pulling

90° for $\vec{n}$ AND 180° for $\vec{F_{el}}$

⇒ only Spring Doing Negative work

(3.) Two kids ride a toboggan from rest at point A down the hill shown. If the amount of friction between the snow and toboggan is negligible, how fast will the kids be going when they smash into the snowman?



(a) 7.7 m/s	(b) 9.4 m/s	(c) 12.1 m/s
(d) 13.1 m/s	(e) There is not enough information to determine	

GRAVITY ONLY FORCE DOING WORK $\Rightarrow \frac{1}{2}\cancel{m}\cancel{V_1^2} + \cancel{m}gy_1 = \frac{1}{2}\cancel{m}V_2^2 + \cancel{mgy_2}$

$V_1 = 0$, $y_1 = 4.5\,m$ (GRAVITY ONLY CARES ABOUT HEIGHT)

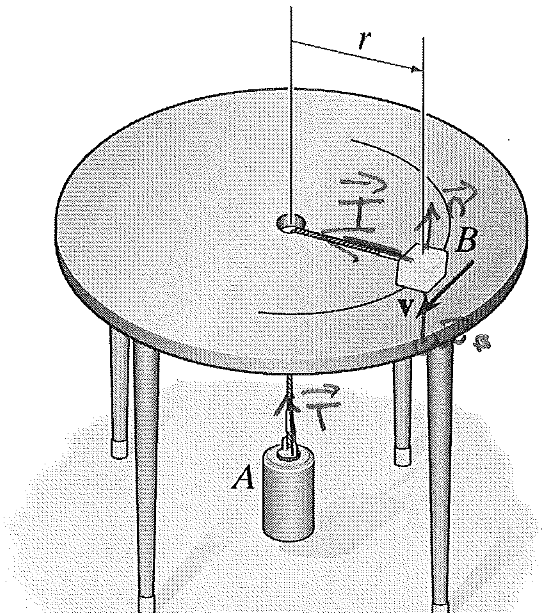
$V_2 = ?$, $y_2 = 0$

$\Rightarrow \cancel{m}gy_1 = \frac{1}{2}\cancel{m}V_2^2 \Rightarrow V_2 = \sqrt{2gy_1} = \sqrt{2(9.8\,m/s^2)(4.5\,m)}$

$= 9.391\,m/s$

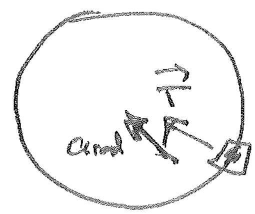
$= 9.4\,m/s$

(4.) Block B, mass $2.5\,kg$ is rotating on a $r = 0.42$-m radius circle with constant speed of $1.5\,m/s$. Ignoring any friction between block B and the table, what is the mass of the hanging block A?



(a) ~~9 kg~~ 17.9 kg	(b) ~~1.37 kg~~ 10.8 kg	(c) ~~2.5 kg~~ 2.5 kg
$\boxed{\text{(d)}}$ ~~10.8 kg~~ 1.37 kg	(e) ~~17.9 kg~~ 0	

ON B



$\vec{T}$ only Force TOWARDS Center

$$\Rightarrow \sum F_x = m a_x \Rightarrow T = M_B \frac{V^2}{r}$$

$$\Rightarrow T = \frac{(2.5\,kg)(1.5\,m/s)^2}{0.42\,m} = 13.39\,N$$

MAssless Rope $\Rightarrow$ SAME Tension ON A

$\uparrow \vec{T}$

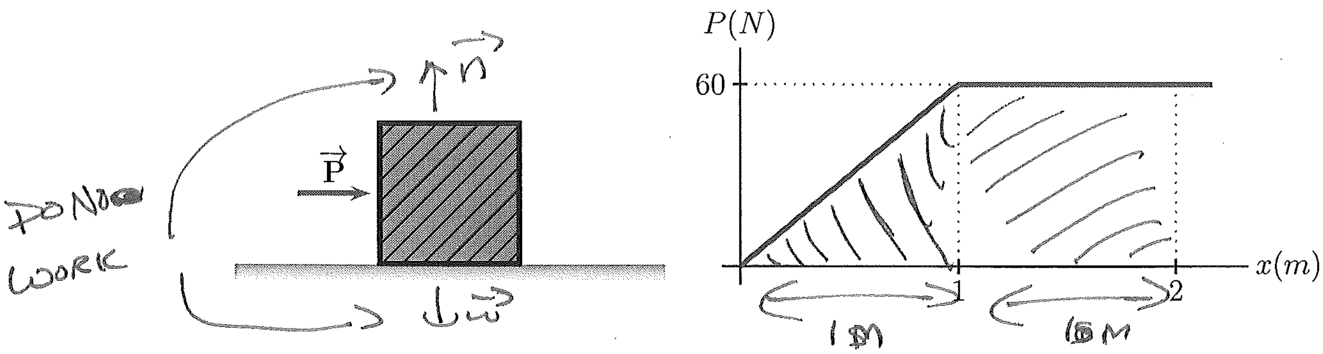
$\downarrow \vec{W_A}$

A NOT Accelerating $\Rightarrow \sum F_y = 0 \Rightarrow T - W_A = 0$

$\Rightarrow W_A = T = 13.39\,N$

$$\therefore M_A = \frac{T}{g} = \frac{13.39\,N}{9.8\,m/s^2} = 1.37\,kg$$

(5.) A 2.5-kg mass is sitting at rest on a frictionless floor when a horizontal but variable force P is applied. If the graph shows the magnitude of P as a function of position, how fast will the mass be going after $2\,m$?



(a) $8.49\,m/s$	(b) $9.80\,m/s$	(c) $11.0\,m/s$	(d) $12.6\,m/s$	(e) $14.1\,m/s$

$\vec{P}$ only force doing work $\Rightarrow W_P = W_{TOTAL} = \frac{1}{2}mV_2^2 - \frac{1}{2}mV_1^2$

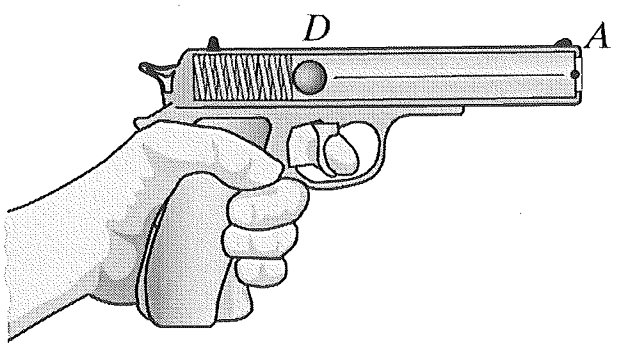
$V_1 = 0 \Rightarrow \frac{1}{2}mV_2^2 = W_P \Rightarrow V_2 = \sqrt{\frac{2W_P}{m}}$

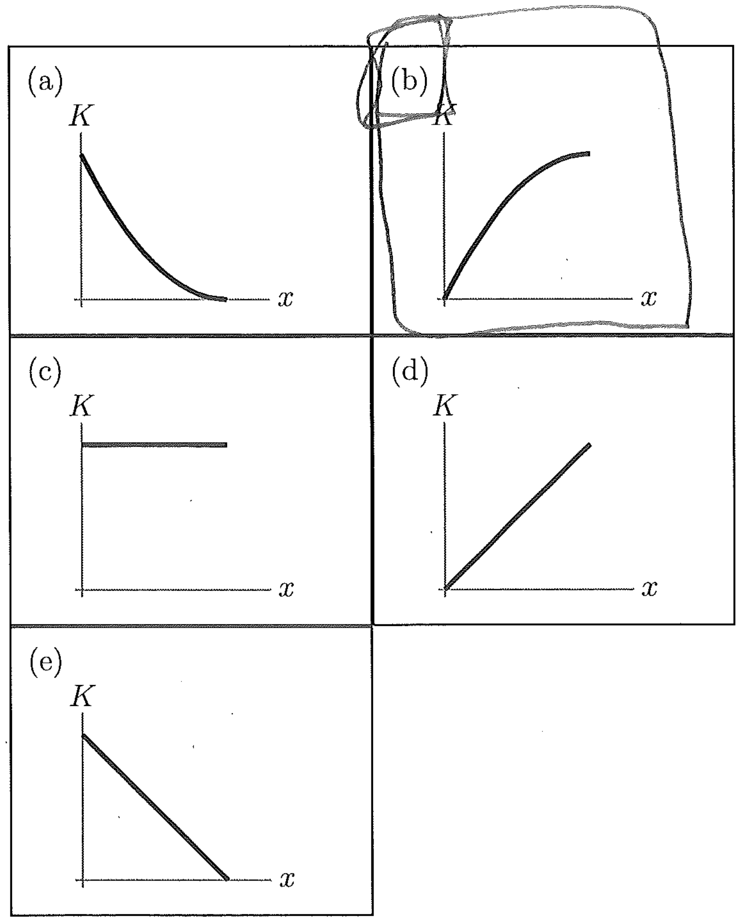
Variable force $\Rightarrow W_P$ = Area $\Rightarrow$ Triangle + Rectangle

$\Rightarrow W_P = \frac{1}{2}(1\,m)(60\,N) + (1\,m)(60\,N) = 30\,J + 60\,J = 90\,J$

$\therefore V_2 = \sqrt{\frac{2(90\,J)}{2.5\,kg}} = 8.485\,m/s$

(6.) A spring gun is loaded by pushing a small ball into the barrel and locking it into place. (During this process the spring is compressed.) When the trigger is pulled, the ball is released from rest at point D. Ignoring friction, which of the following graphs shows the system's kinetic energy as the ball travels from point D to point A. Assume the spring is always pushing on the ball and is uncompressed when the ball reaches point A.





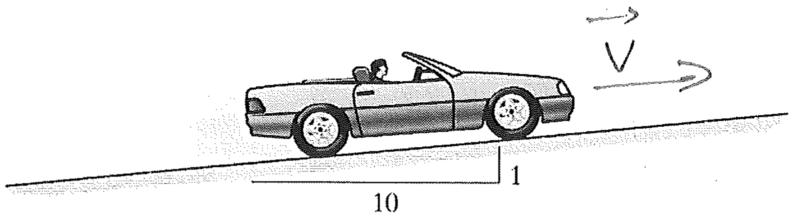
Spring only force Doing work From D to A since Barrel is Horizontal $\Rightarrow E = K + U_{el}$ is conserved $\Rightarrow E = K + \frac{1}{2}kS^2$

$\Rightarrow K = E - \frac{1}{2}k(x - l_0)^2 \Rightarrow$ Kinetic Energy graph is Parabola. Starts From Rest & K starts at Zero

Uncompressed length

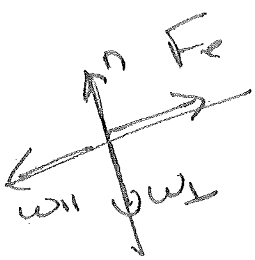
(7.) What power must the engine in this 2000-kg car generate in order for it to go up a 10%-grade hill with constant speed of 15 m/s. For simplicity ignore all retarding forces. (Please notice the use of kW - Kilowatts in order to make the numbers smaller.)

(a) ~~0 kW~~ 294 kW	(b) ~~29.3 kW~~ 38.4 kW	(c) ~~38.4 kW~~ 29.4 kW
(d) ~~294 kW~~ 0	(e) There is not enough information to determine.	



Still have gravity & engine force, $\vec{F_e}$ parallel to incline

$\therefore \quad \vec{V} \rightarrow \vec{F_e} \quad P = \vec{F_e} \cdot \vec{V} = F_e V \cos 0^\circ = F_e V$



Constant Speed $\Rightarrow \sum F_{\parallel} = 0 \Rightarrow F_e - W_{\parallel} = 0$

$\Rightarrow F_e = W_{\parallel} = mg\sin\alpha$

$\tan\alpha = \frac{1}{10} \Rightarrow \alpha = \tan^{-1}\left(\frac{1}{10}\right) = 5.71^\circ \Rightarrow F_e = (2000kg)(9.8m/s^2)\sin 5.71^\circ$

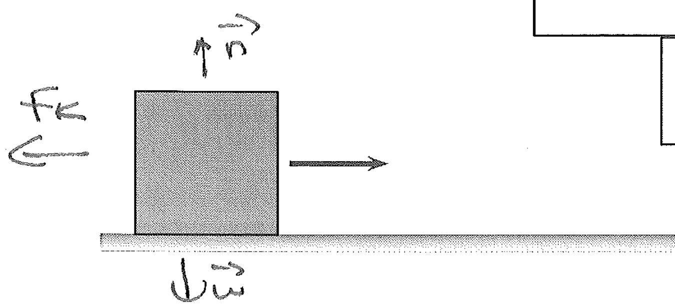
$= 1950.3N$

$P = F_e V = (1950.3N)(15m/s) = 29254\,Watt \times \frac{kW}{1000\,watt} = 29.254\,kW$

$= 29.3\,kW$

(8.) A 10 kg mass initially sliding to the right is stopped by friction. If this process creates 75 J of thermal energy, how fast was the mass initially going?

(a) 2.74 m/s	(b) 3.16 m/s	(c) 3.87 m/s
(d) 4.47 m/s	(e) There is not enough information to determine.	



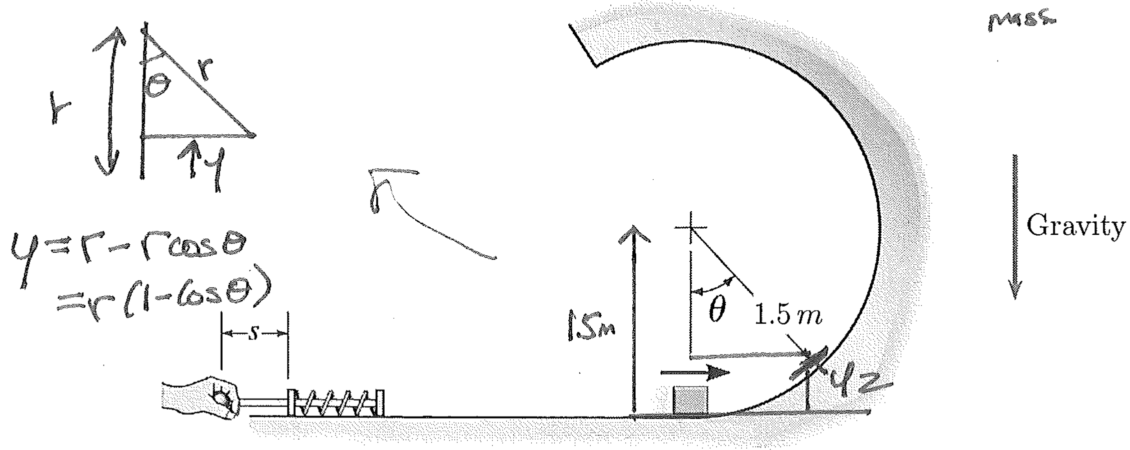
Friction only force doing work $\quad W_f = -\Delta E_{TH} = -75J$

$$W_f = W_{TOTAL} = \frac{1}{2}mV_2^2 - \frac{1}{2}mV_1^2$$

$$V_2 = 0,\ V_1 = ? \Rightarrow W_f = 0 - \frac{1}{2}mV_1^2 = -\frac{1}{2}mV_1^2$$

$$\Rightarrow V_1 = \sqrt{\frac{-2W_f}{m}} = \sqrt{\frac{-2(-75J)}{10kg}} = \sqrt{15\,m^2/s^2} = 3.87\,m/s$$

(9.) A 1500-N/m spring is used to launch from rest a 3.0-kg block across a frictionless table and towards a 1.5-m radius circle. (The circle is also frictionless, and the spring is no longer in contact with mass.) The block reaches the angle $\theta = 40°$ with a speed of $8.0\, m/s$.



Spring Does work During launch. Gravity Does work when it goes into Circle But Doesn't matter, we can combine them

(a) How far was the spring compressed in order to launch the block? *(+10pts)*

$$\frac{1}{2}\cancel{mv_1^2} + \cancel{mgy_1} + \frac{1}{2}ks_1^2 = \frac{1}{2}mv_2^2 + mgy_2 + \cancel{\frac{1}{2}ks_2^2}$$

$V_1 = 0$, $V_2 = 8m/s$, $y_1 = 0$; $y_2 = 1.5m(1-\cos 40°) = 0.35m$

$S_1 = ?$, $S_2 = 0$ (MASS NOT TOUCHING Spring Anymore)

$\therefore \frac{1}{2}(1500N/m)(S_1)^2 = \frac{1}{2}(3kg)(8m/s)^2 + (3kg)(9.8m/s^2)(0.35m)$

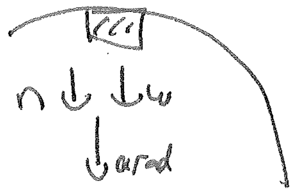
$\Rightarrow \frac{1}{2}(1500N/m)S_1^2 = 96J + 10.29J = 106.29J$

~~Part (b) is on the back.~~ $\therefore S_1 = \sqrt{\dfrac{2(106.29J)}{1500N/m}} = 0.376m$

$= 37.6cm$

(b) Does the block make it over the top of the circle? For full points, you must do a correct numerical calculations along with an explanation. *(+10pts)*

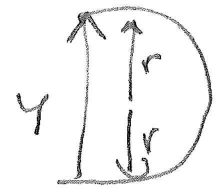
THE MINIMUM Speed to make it over the top of a Circle occurs when NORMal force Becomes ZERO



$n = 0 \;\Rightarrow\; \sum F_y = ma_y \;\Rightarrow\; w = ma_{rad}$ (Down is Negative)

$\Rightarrow mg = \dfrac{m v_{min}^2}{r} \;\Rightarrow\; v_{min} = \sqrt{rg} = \sqrt{(1.5m)(9.8m/s^2)}$

$= 3.834 m/s$



AT Top of circle $y = 2r = 3m$

$\therefore \; \frac{1}{2}kS_1^2 = \frac{1}{2}mV_2^2 + mgy_2$ with $V_2 = ?$, $y_2 = 3m$

$\therefore \; \frac{1}{2}(1500 N/m)(0.376m)^2 = \frac{1}{2}(3kg)V_2^2 + (3kg)(9.8m/s^2)(3m)$

$\Rightarrow 106.29J = \frac{1}{2}(3kg)V_2^2 + 88.2J$

Should look Familiar

$\Rightarrow V_2 = \sqrt{\dfrac{2(106.29J - 88.2J)}{3kg}} = \sqrt{\dfrac{2(18.09J)}{3kg}}$

$= 3.473 m/s$

NOPE. Doesn't MAKE IT