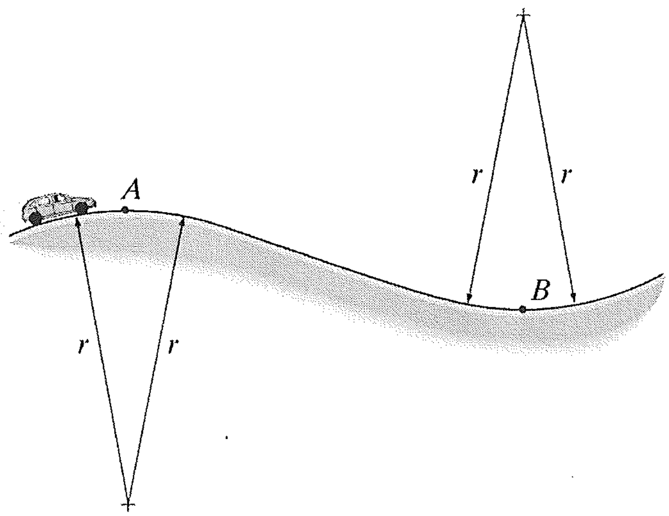
(1.) A car drives along a road with constant speed. If, as shown, the road can be approximated as parts of two equal radii circles, at which point does the driver's apparent weight have its largest value?



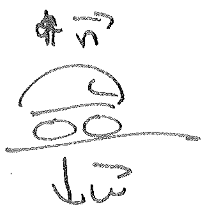

| | |
|---|---|
| (a) Point $A$. | (b) Point $B$. |
| (c) Both $A$ and $B$ have the same maximum apparent weight. | |
| (d) Neither $A$ nor $B$. The maximum occurs when the car is driving on a flat road. | |
| (e) It cannot be determined without knowing the speed of the car. | |

At A: $\uparrow\vec{n}$ $\downarrow\vec{a}_{rad}$ $\downarrow\vec{w}$ $\quad \sum F_y = ma_y \Rightarrow n - w = m(-a_{rad}) = -\frac{mv^2}{r}$

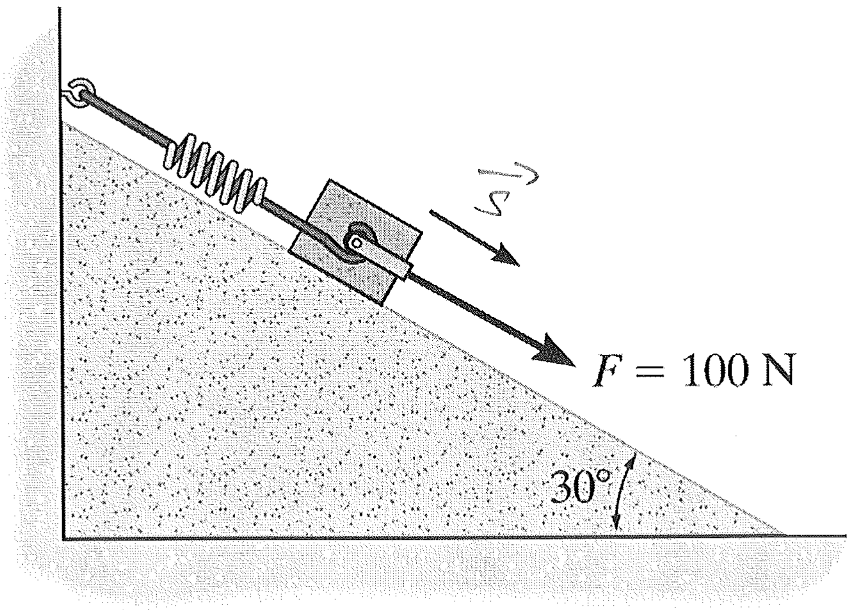
$\therefore n = w - \frac{mv^2}{r} \leftarrow n < w$ FOR any $v$

At B: $\uparrow\vec{n}$ $\uparrow\vec{a}_{rad}$ $\downarrow\vec{w}$ $\quad \sum F_y = ma_y \Rightarrow n - w = m(+a_{rad}) = +\frac{mv^2}{r}$

$\therefore n = w + \frac{mv^2}{r} \leftarrow n > w$ for any $v$

ON FLAT ROAD:  No Acceleration $\Rightarrow n = w$

(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?

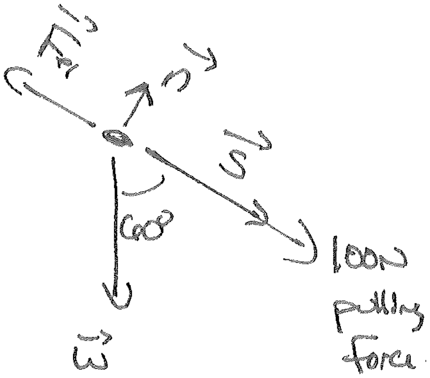



| |
|---|
| (a) Gravity. |
| (b) The spring force. |
| (c) The pulling force. |
| (d) The normal force. |
| (e) Both gravity and the spring force. |

Intuitively : Spring only force trying to slow MASS DOWN

$\Rightarrow$ only one Doing Negative Work

MATH:




$\phi = 0°$ for pulling

$60°$ for $\vec{w}$

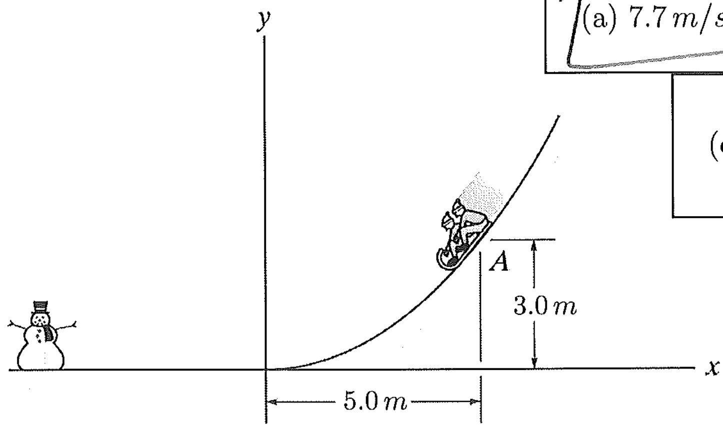
$90°$ for $\vec{n}$

$180°$ for $\vec{F}_{el}$

$W = \vec{F} \cdot \vec{s} = Fs\cos\phi$ OR $\int F\cos\phi\, ds$

$\Rightarrow$ Spring only force doing 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) $9.9\,m/s$ | (c) $10.7\,m/s$ |
| (d) $12.1\,m/s$ | (e) There is not enough information to determine | |

Gravity only force doing work $\Rightarrow \cancel{\frac{1}{2}mv_1^2} + mgy_1 = \frac{1}{2}mV_2^2 + \cancel{mgy_2}$

$V_1 = 0$, $y_1 = 3m$ (gravity only cares about height)

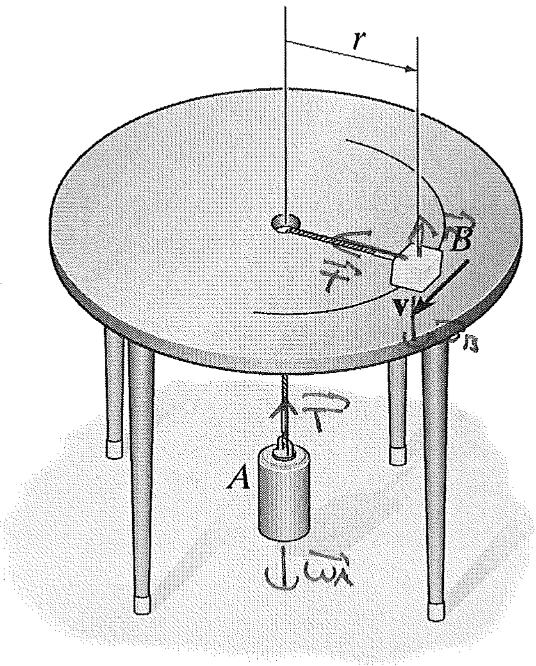
$V_2 = ?$, $y_2 = 0$

$\therefore \cancel{m}gy_1 = \frac{1}{2}\cancel{m}V_2^2 \Rightarrow V_2 = \sqrt{2gy_1} = \sqrt{2(9.8m/s^2)(3m)}$

$= 7.668 m/s$

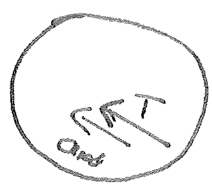
$= 7.7 m/s$

(4.) Block $B$, mass $4.2\,kg$ is rotating on a $r = 0.15$-$m$ radius circle with constant speed of $2.5\,m/s$. Ignoring any friction between block $B$ and the table, what is the mass of the hanging block $A$?




| | | |
|---|---|---|
| (a) $17.9\,kg$ | (b) $10.8\,kg$ | (c) $4.2\,kg$ |
| (d) $1.37\,kg$ | (e) $0\,kg$ | |

ON B: $\vec{T}$ only force towards center



$\sum F_x = ma_x$

$\Rightarrow T = m_B a_{rad} = \frac{m_B v^2}{r}$

$\therefore T = \frac{(4.2kg)(2.5m/s)^2}{0.15m} = 175N$

Massless rope $\Rightarrow$ same tension on A

$\uparrow \vec{T}$

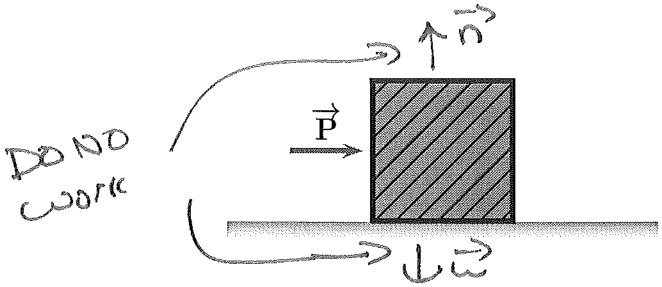
$\downarrow \vec{\omega}_A$

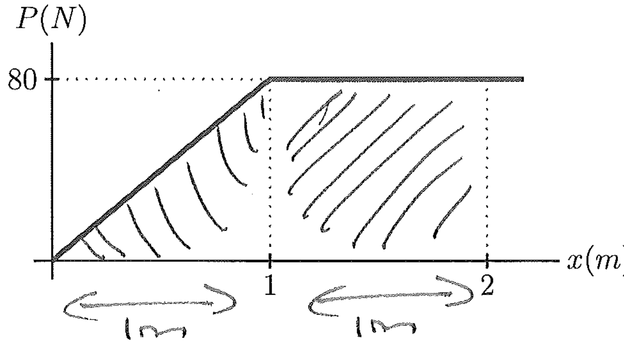
A not accelerating $\Rightarrow \sum F_y = 0 \Rightarrow T - \omega_A = 0$

$\Rightarrow \omega_A = T = 175N$

$m_A = \frac{\omega_A}{g} = \frac{175N}{9.8m/s^2} = 17.857kg = 17.9kg$

(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 $\Rightarrow W_P = \frac{1}{2}mV_2^2 - \frac{1}{2}mV_1^2$

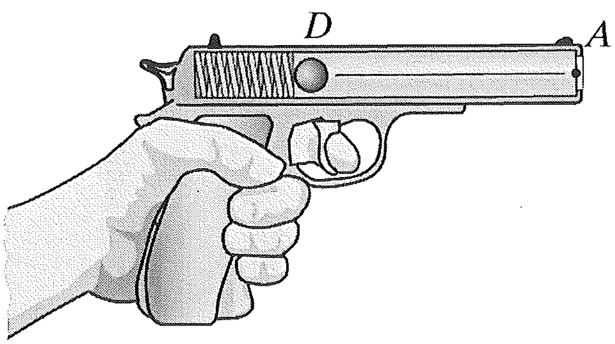
$V_2 = ?,\ V_1 = 0 \Rightarrow W_P = \frac{1}{2}mV_2^2 \Rightarrow V_2 = \sqrt{\frac{2W_P}{m}}$

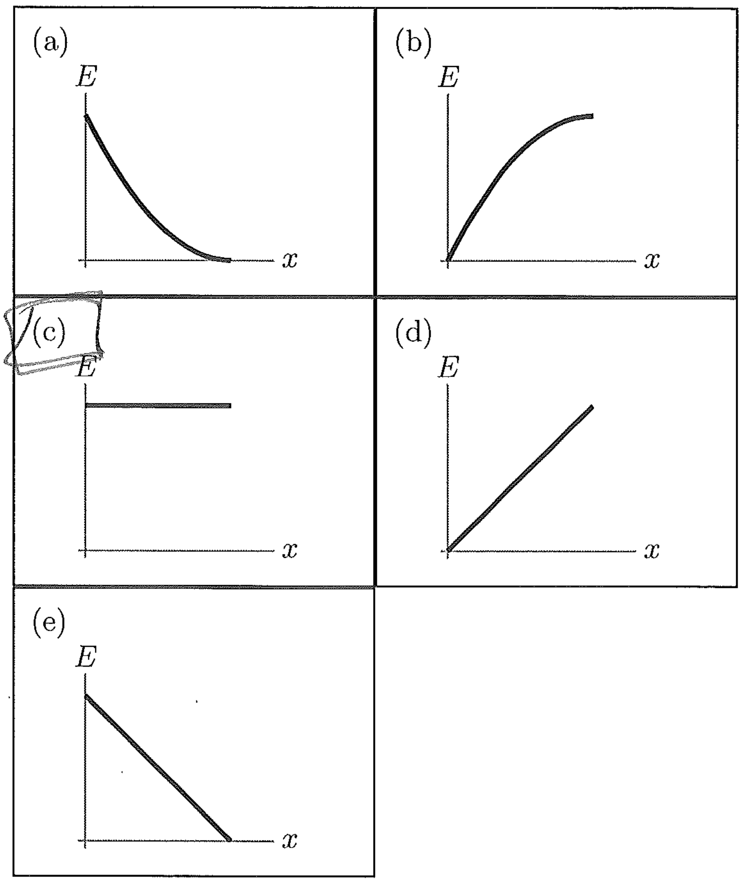
Variable Force $\Rightarrow W_P$ = AREA = Triangle + Rectangle

$W_P = \frac{1}{2}(1m)(80N) + (1m)(80N) = 40J + 80J = 120J$

$\therefore V_2 = \sqrt{\frac{2(120J)}{2.5kg}} = 9.7979\,m/s = 9.80\,m/s$

(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 total 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 $A$.



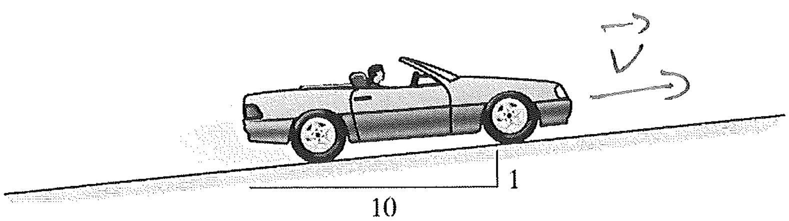

Barrel Horizontal $\Rightarrow$

Spring only force

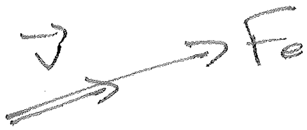
Doing work $\Rightarrow$ $E = K + U_{el}$ is Conserved $\Rightarrow$ Constant

(7.) What power must the engine in this 2400-$kg$ car generate in order for it to go up a 10%-grade hill with constant speed of $12.5\,m/s$. For simplicity ignore all retarding forces. (Please notice the use of $kW$ - Kilowatts in order to make the numbers smaller.)

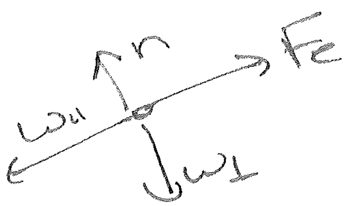
| | | |
|---|---|---|
| (a) $294\,kW$ | (b) $38.4\,kW$ | (c) $29.3\,kW$ |
| (d) $0\,kW$ | (e) There is not enough information to determine. | |




Still have Engine Force & Gravity. $\vec{F}_e$ parallel to ROAD.




$$P = \vec{F}_e \cdot \vec{v} = F_e v \cos 0° = F_e v$$




NO ACCELERATION $\Rightarrow \sum F_{\parallel} = 0$

$$\Rightarrow F_e - W_{\parallel} = 0 \Rightarrow F_e = W_{\parallel} = mg\sin\alpha$$

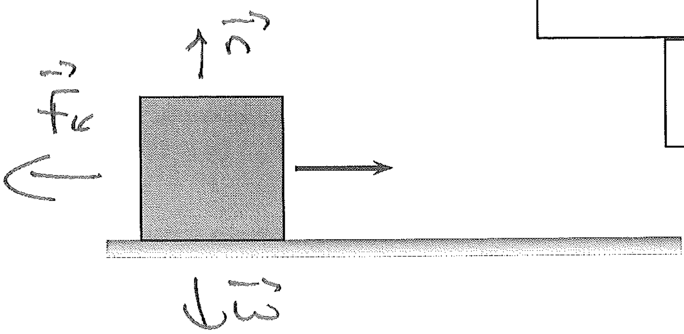
$$\tan\alpha = \frac{1}{10} \Rightarrow \alpha = \tan^{-1}\left(\frac{1}{10}\right) = 5.71°$$

$$\therefore F_e = (2400kg)(9.8m/s^2)\sin 5.71° = 2340N$$

$$P = F_e v = (2340N)(12.5m/s) = 29254\,Watt \times \frac{kW}{1000\,Watt} = 29.254\,kW$$

(8.) A 10 $kg$ mass initially sliding to the right is stopped by friction. If this process creates 100 $J$ of thermal energy, how fast was the mass initially going?

| | | |
|---|---|---|
| (a) 3.16 $m/s$ | (b) 3.87 $m/s$ | $\boxed{\text{(c) } 4.47\, m/s}$ |
| (d) 10 $m/s$ | (e) There is not enough information to determine. | |



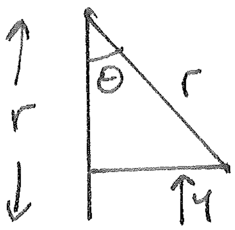

$f_k$ only force Doing work $\Rightarrow W_f = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$v_2 = 0,\ v_1 = ? \Rightarrow W_f = -\frac{1}{2}mv_1^2 \Rightarrow v_1 = \sqrt{\frac{-2W_f}{m}}$

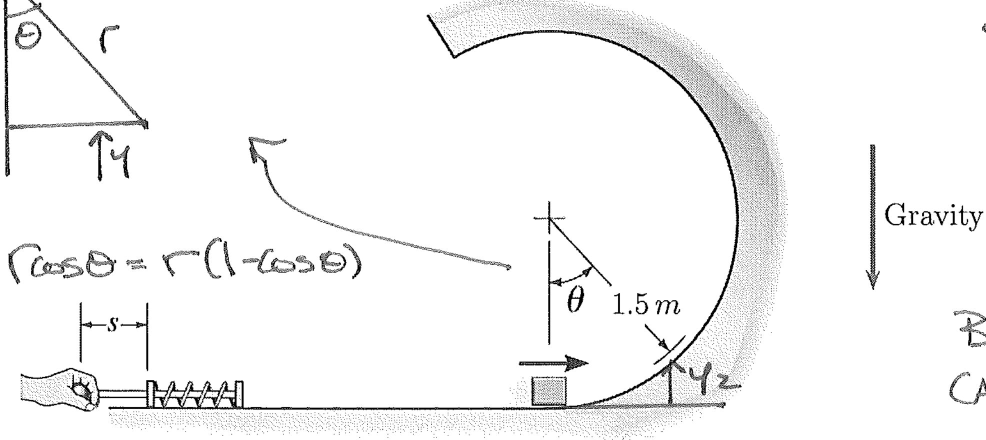
$W_f = -\Delta E_{TH} = -100J \quad \therefore \quad v_1 = \sqrt{\frac{-2(-100J)}{10kg}} = \sqrt{+20\, m^2/s^2}$

$= 4.47\ m/s$

(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 touching the block when it enters the circle.) The block reaches the angle $\theta = 30°$ with a speed of $8.2\,m/s$.




$y = r - r\cos\theta = r(1-\cos\theta)$




Spring Does work During launch and gravity only when it enters circle, But Doesn't matter we can still combine

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

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

$V_1 = 0$, $V_2 = 8.2\,m/s$

$y_1 = 0$, $y_2 = 1.5m(1-\cos 30°) = 0.2m$

$S_1 = ?$, $S_2 = 0$ (not touching anymore so no potential)

$$\therefore \tfrac{1}{2}(1500N/m)S_1^2 = \tfrac{1}{2}(3kg)(8.2m/s)^2 + (3kg)(9.8m/s^2)(0.2m)$$

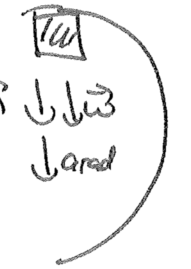
$$= 100.86J + 5.88J = 106.74J$$

$$\therefore S_1 = \sqrt{\frac{2(106.74J)}{1500N/m}} = 0.377m = 37.7cm$$

Part (b) is on the back.

(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)*

To make it over, its speed must be bigger than $V_{min}$.



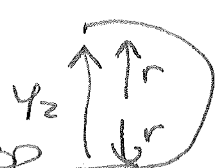

$V_{min} \Rightarrow n=0$ at top

$\sum F_y = ma_y$ & $n=0 \Rightarrow w = ma_{rad} = \frac{mv^2}{r}$ (Down is positive)

$\therefore mg = \frac{m V_{min}^2}{r} \Rightarrow V_{min} = \sqrt{rg} = \sqrt{(1.5m)(9.8m/s^2)} = 3.834 m/s$

To Find speed at top, CAN still start at LAUNCH

$\Rightarrow \frac{1}{2}ks_1^2 = \frac{1}{2}mv_2^2 + mgy_2$ But at top




$y_2 = 2r = 3m$

$\therefore \frac{1}{2}(1500N/m)(0.377m)^2 = \frac{1}{2}(3kg)V_2^2 + (3kg)(9.8m/s^2)(3m)$

$\Rightarrow 106.74J = \frac{1}{2}(3kg)V_2^2 + 88.2J$

looks Familiar

$\Rightarrow V_2 = \sqrt{\frac{2(106.74J - 88.2J)}{3kg}} = \sqrt{\frac{2(18.54J)}{3kg}}$

$= 3.515 m/s$

Doesn't make it