Homework #2

1) a) $g_{new} = \frac{2}{3} g_{surface}$ $\qquad r_e = 6.371 \times 10^3 \text{ km}$

$$F_g = \frac{G m_{earth} m_{object}}{r^2} = m_{object}\, g$$

$\Rightarrow g = \frac{G m_{earth}}{r^2}$ we are looking for the radius though

$$r = \sqrt{\frac{G m_{earth}}{g}} \qquad r_{new} = \sqrt{\frac{G m_{earth}}{g_{new}}} = \sqrt{\frac{G m_{earth}}{\frac{2}{3} g_{surface}}}$$

$$= \sqrt{\frac{3}{2} \underbrace{\frac{G m_{earth}}{g_{surface}}}_{\text{this equals the } r_{earth\text{'s surface}}}} = \sqrt{\frac{3}{2}}\, r_{earth}$$

$$r_{new} = \sqrt{\frac{3}{2}} \left(6.371 \times 10^3 \text{ km}\right)$$

$$= 7.803 \times 10^3 \text{ km}$$

now subtract 6.371×10^3 km to get 1.432×10^3 km

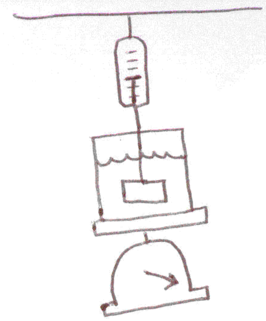
b) $g_{new} = \frac{1}{3} g_{surface}$

we can use the same equation from part a, but now we have

$$r_{new} = \sqrt{3} \left(6.371 \times 10^3 \text{ km}\right) = 1.103 \times 10^4 \text{ km}$$

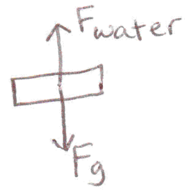
subtract 6.371×10^3 km to get 4.659×10^3 km

2)



a) the spring scale measures 15.8 N
what is the upward force?

First, draw a free body diagram for the brick.



The spring scale measures the net force on the brick.

$F_{net} = F_{water} + F_g$

Lets say that down is negative and up is positive.

We know that the brick has a mass of 3.00 Kg

We also know $F_g = mg = (3.00\,Kg)(9.8\,m/s^2) = 29.4\ \frac{Kg\,m}{s^2} = 29.4\,N$

So we know F_{net} and we know F_g and we want to know F_{water} because that is what is pushing up on the brick.

$F_{water} = F_{net} - F_g = (-15.8N) - (-29.4N) = 29.4N - 15.8N = 13.6N$

So the upward force is 13.6 N

b) What is the reading of the pan scale?
The water + the beaker has weight 11.0 N

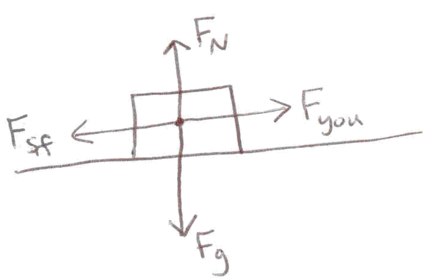
In part a we found the upward force of the water on the brick to be 13.6N. The action ~~and~~ reaction pair to this force is the force of the brick pressing down on the water. That force increases the amount the water presses on the scale by 13.6N. So the scale will read the 11.0N from the weight of the water and beaker plus the extra force of the block pushing on the water. $= 11.0N + 13.6N = 24.6N$

3) Normal force of the floor on a box = 236 N

a) You exert a force of 124 N horizontally on the box

$F_{\substack{\text{static}\\\text{friction}}} < \mu_s F_N \Rightarrow \frac{F_{sf}}{F_N} < \mu_s$

$F_{\substack{\text{static}\\\text{friction}}}$ = - the force you exert on the box (see the free body diagram)



Because the box doesnt move horizontally we know $F^H_{net} = 0 = F_{you} + F_{sf} \Rightarrow F_{sf} = -F_{you}$

$F_{sf} = 124N$

back to $\mu_s > \frac{F_{sf}}{F_N} \Rightarrow \mu_s > \frac{124N}{236N}$

$\mu_s > .53$

b) To get the box moving you must exert a force of 135 N.

$\mu_s = ?$

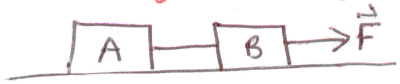
From $F_{sf} = \mu_s F_N$ $\quad \mu_s = \frac{F_{sf}}{F_N} = \frac{135N}{236N} = .57$

c) Once the box is sliding, you only have to push with a force of 111 N to keep it sliding. What is μ_K?

$F_{Kf} = \mu_K F_N$ $\quad \mu_K = \frac{F_{Kf}}{F_N} = \frac{111N}{236N} = .47$

4) $\mu_s = .51$ $\quad$ $\mu_s = .45$

$m = 1\,Kg$ $\quad$ $m = 1\,Kg$

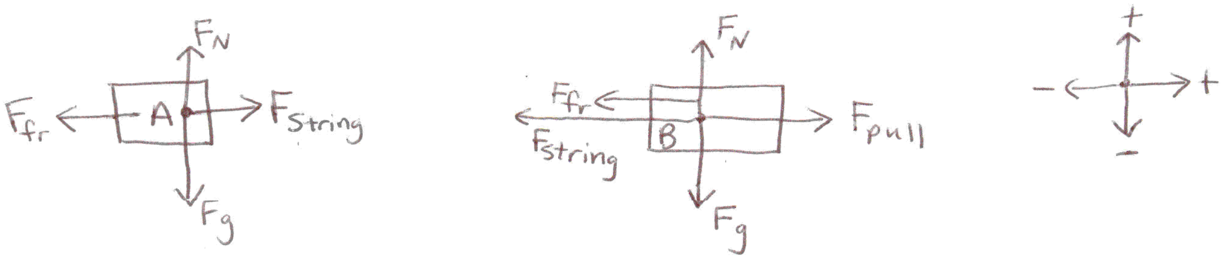


a) What force is needed to barely get both blocks moving?

They both have $m = 1\,Kg$ so they both have normal force

$$F_N = (1Kg)(9.8\,m/s^2) = 9.8\,N$$

Our free body diagrams are:



The F_{String} pulling on block A needs to be just enough to get A moving, so $F_{string} = \mu_s(A)\,F_N(A) = (.51)(9.8N) = 5N$

This is equal to the Force of the String pulling on block B.

$F_{fr}(B) = \mu_s(B)\,F_N(B) = (.45)(9.8N) = 4.41\,N$

$\vec{F}^{\,H}_{net}(B) = \vec{F}_{fr}(B) + \vec{F}_{String} + \vec{F}_{pull} = 0$

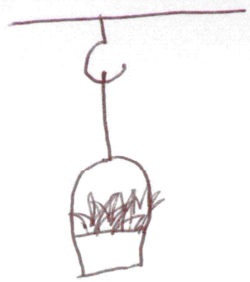
$$F_{pull} = -F_{fr}(B) - F_{string} = -(-4.41N) - (-5N) = 9.41\,N$$

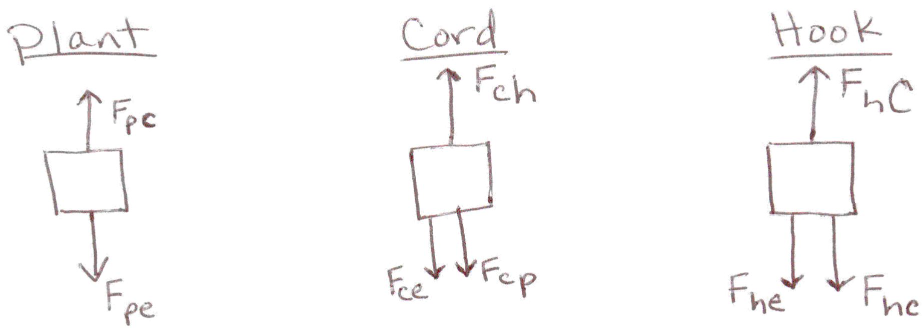
b) What is the tension in the string at that same instant?

tension in the string is what I have called F_{string}

$\Rightarrow$ Tension $= 5N$

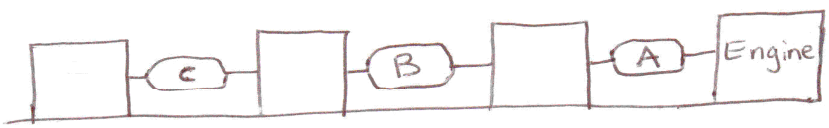
5) The correct free body diagrams are:





p = plant system
c = cord
e = Earth
h = hook
C = ceiling

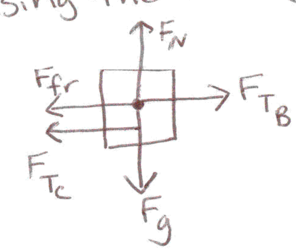
6)



all moving →
Constant velocity

a) Because all the cars and engine are moving at a constant speed with no friction, the 3 scales all read 0.
(There are no horizontal forces acting on the train)

b) Now friction and air resistance are involved.
Using the hint given, lets draw a free body diagram of the midde car.



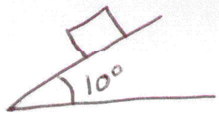
(I am including $f_{\text{air resistance}}$ in F_{friction})

If we think about the car on the far left, it wont have any tension forces pulling it to the left so the spring scale C will read the least of all 3 scales. Spring scale B will have 2 cars worth of friction pulling to the left, A will have 3 cars worth of friction pulling to the left.

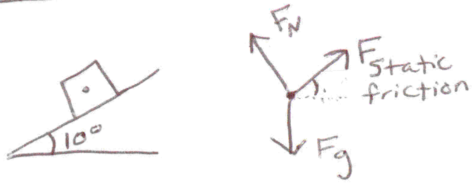
So A>B>C

c) $F_{fr} = 5.5N$ for each car.
$C = 5.5N$ (1 car pulling to the left)
$B = 5.5N + 5.5N = 11N$ (2 cars pulling to the left)
$A = 5.5N + 5.5N + 5.5N = 16.5N$ (3 cars pulling to the left)

7)

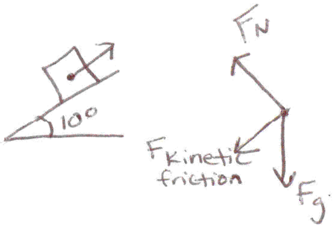


a)



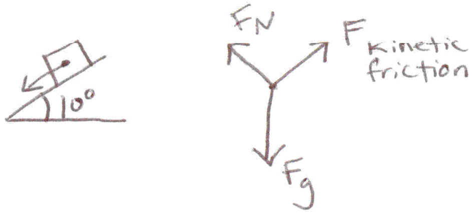
at rest

b)



Sliding up the incline

c)



Sliding down the incline

The normal force is perpendicular and away from the ramp.

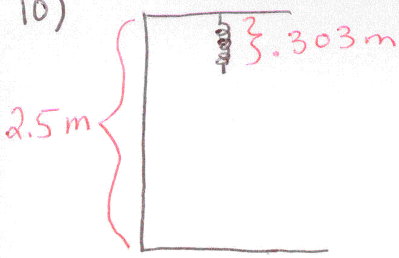
Friction on the crate

a) along ramp upward

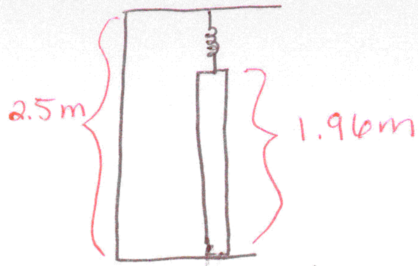
b) along ramp downward

c) along ramp upward

10)



Before Board is added



After Board is added

First we need to find out how much the spring is stretched after the board is added.

So we subtract the length of the board from the height of the room.

$$X_{\substack{\text{stretched}\\ \text{spring}}} = 2.5\,m - 1.96\,m = .54\,m$$

This means the spring has been stretched by

$$X_{\substack{\text{stretched}\\ \text{spring}}} - X_{\substack{\text{unstretched}\\ \text{spring}}} = .54\,m - .303\,m = .237\,m$$

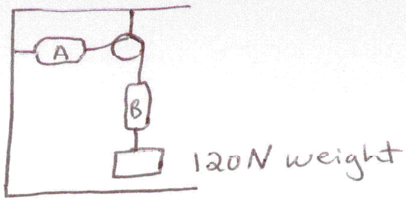
We know $F = KX$

In this equation $X = X_{\text{stretched}} - X_{\text{unstretched}}$

and $F = \text{weight of the board} = m_{board}\,g = (10.1\,Kg)(9.8\,\frac{N}{Kg}) = 98.98\,N$

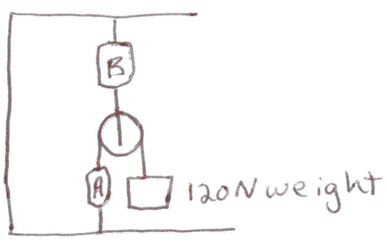
$$K = \frac{F}{X} = \frac{98.98\,N}{.237\,m} = 417.64\ N/m$$

8) a)



the pulley only changes the direction of the string, not the tension in the string.
$\Rightarrow$ Scale A = Scale B = 120N

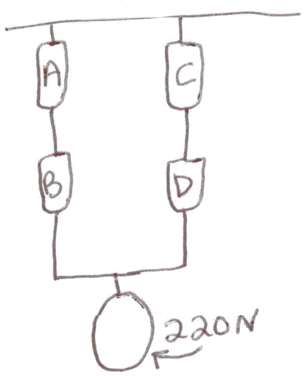
b)



The pulley only changes the direction of the string
$\Rightarrow$ Scale A reads 120N

Scale B has the 120N weight plus the force from the left side of the pulley because the spring scale is attached to the floor.
$\Rightarrow$ Scale B reads 240N

9)



a) The scales are massless. Each side of the scale system will be holding up half of the weight hanging. So each side will have 110 N pulling down on it.
Scale A and B will both read the same amount of weight because the scales are not adding any weight to the system
$\Rightarrow$ Scale A = B = C = D = 110 N

b) Now The scales have weight = 5.0 N.
Scales B and D still only feel the force of the potatoes pulling down on them so scale B = D = 110 N

But now Scales A and C feel the potatoes and scales B and D respectively. $\Rightarrow$ Scales A and C both measure a force of 115N