Due **Friday Oct 8..beginning of class.** **Pset #1- Dynamics ANSWERS**

Problem 1. System and Interactions.

In the following situations:

*i) Define the **system** and the environment:*
- Identify which objects - the environment - interact with the object of interest- the **system**.

*ii) Describe the **interactions** and the resulting forces*:
- Identify the **forces** exerted on the object of interest by the other objects.

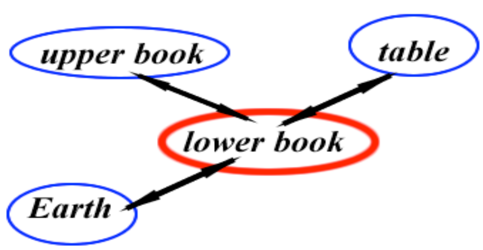
*iii) Draw the **free body diagram** of the object.*
- Make sure that each force arrow is labeled with two subscripts – who is exerting the force and on whom is the force being exerted $F_{\text{on A by B}} \Leftrightarrow F_{AB}$
- The length of the arrows should represent qualitatively the magnitude of the force.

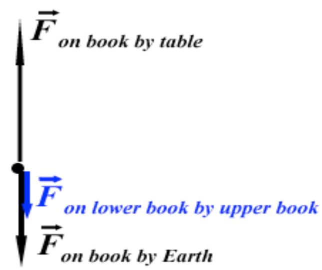
a) Two physics textbooks are sitting on a table, one on top of the other. What are the forces exerted on the lower book?
Solution:

$F_{Bt} = N_{bt}$

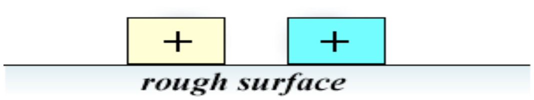
$F_{B\ \text{upper book}} = N_{B\ ub}$

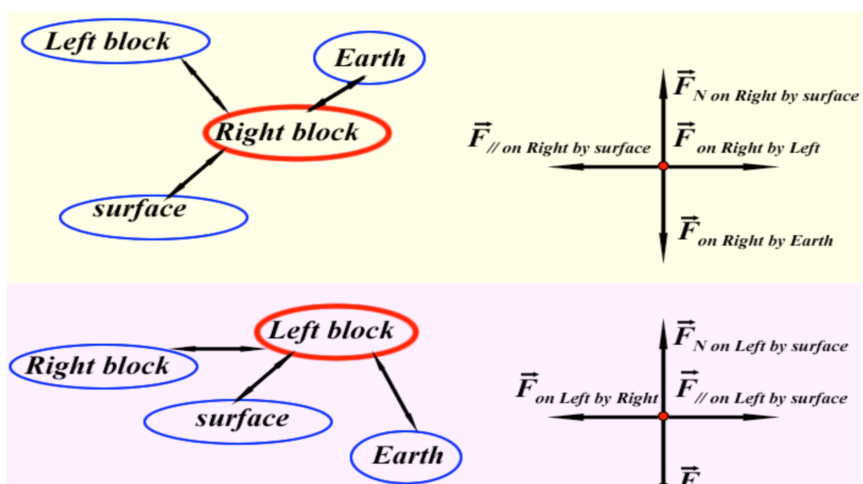
$F_{bE} = W_{bE}$





b) Two positively charged blocks of the same mass are at rest on a horizontal rough surface. The right block has twice the charge of the left block. What are the forces exerted on both blocks?





Solution:
On Right block

F_{RL}

$F_{RE} = W_{RE}$

$F_{Rsurface} = f_{Rsurface}$

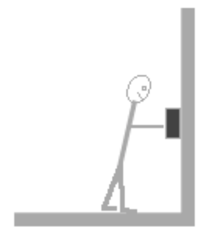
$F_{Rsurface} = N_{Rsurface}$

On Left Block

F_{RL} $F_{LE} = W_{LE}$ $F_{Lsurface} = f_{Lsurface}$

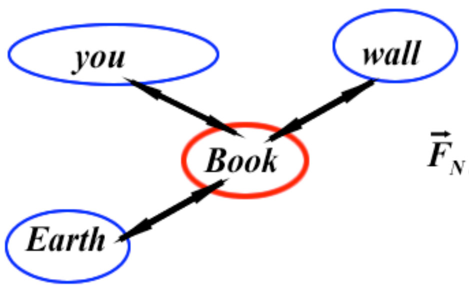
$F_{Rsurface} = N_{Rsurface}$

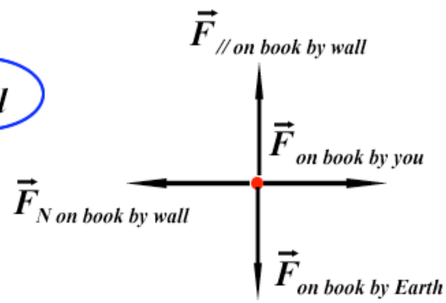
c) You are holding your physics textbook against the wall (see figure). What are the forces exerted on the book?



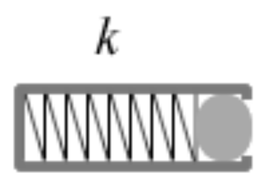
Solution:

$F_{BWall} = N_{BWall}$ F_{BYou} $F_{BE} = W_{BE}$ $F_{BWall} = f_{Bwall}$



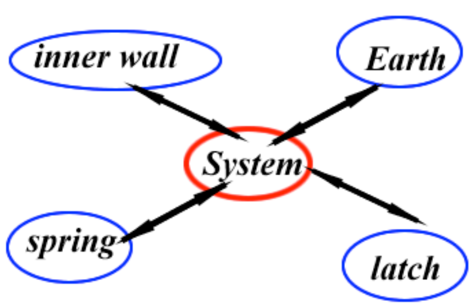


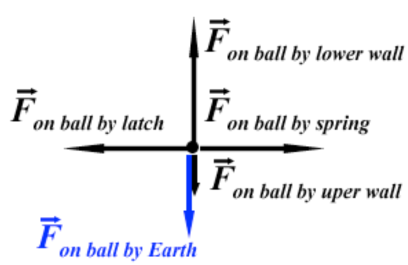
d) A toy gun consists of a spring of constant *k* placed inside a cylinder with an opening at one end as shown in the figure. There is no friction in the inner wall of the cylinder. The toy works by inserting inside the cylinder a light rubber ball through the opening. The ball remains at rest between the compressed spring and a latch at the front end until the gun is fired.



What are the forces exerted on the ball at the instant before firing the gun?

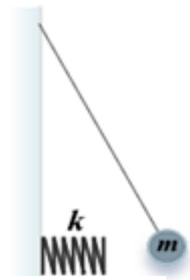
Solution: F_{Blatch} $F_{BSpring}$ $F_{B\text{ lower Wall}} = N_{B\text{ low wall}}$ $F_{B\text{ Upper Wall}} = N_{B\text{ Up Wall}}$
$F_{BEarth} = W_B$





Note. The FBD shown above is an approximation. For example, we are not including the possible forces exerted by the side walls on top and bottom or all around the spring.

e) A ball of mass *m*, held by a string attached to a vertical wall, is released from an initial angle of 35^{o} with respect to the vertical. The ball hits the free end of a horizontal spring attached to the same wall. What are the forces exerted on the ball when the spring is compressed a distance of 0.2 cm with respect to its equilibrium position? (The ball stops moving temporarily when the spring is compressed a distance of 0.4 cm with respect to its equilibrium position).

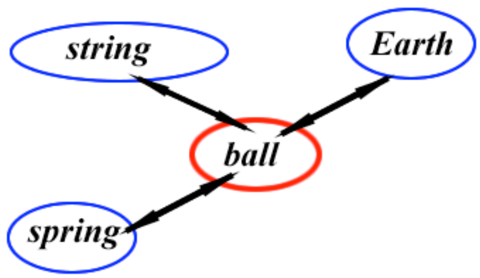


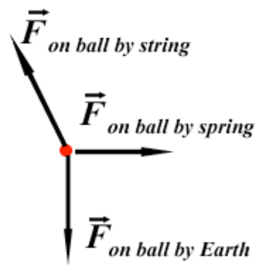
Solution:

$F_{BString} = T_{BString}$

$F_{BSpring}$

F_{BE}





Problem 2: For each of the situations presented in problem 1, describe the properties of the forces acting on the system by completing the following table:

a)	Forces on lower book	Obey a Force Law? No /yes (which one?)	Is a fundamental force?	Does it impose a constraint?
$F_{Bt} = N_{bt}$	Normal support by table	N1,N2,N3	NO	Yes
$F_{B\ upper\ book} = N_{B\ ub}$	Normal force by top book	N1,N2,N3	NO	yes
$F_{bE} = W_{bE}$	Weight of book by Earth	N1,N2,N3 and $F=GM_1m_2/R^2$	Yes, gravitational	no
b)	Forces on right block	Obey a Force Law? No /yes (which one?)	Is a fundamental force?	Does it impose a constraint ?
F_{RL}	Electric force	N1,N2, N3 and Coulomb's force law (if you happen to know this from Chem)	YES, Electromagnetic	no
$F_{RE} = W_{RE}$	Weight of R object	N1,N2,N3 and	YES,	no

		$F=GM_1m_2/R^2$	Gravitational	
$F_{Rsurface} = f_{Rsurface}$	Friction by rough surface on object	N1,N2, N3	No	No
$F_{Rsurface} = N_{Rsurface}$	Normal support force by surface on	N1,N2, N3	NO	yes
c)	Forces on book	Obey a Force Law? No /yes (which one?)	Is a fundamental force?	Does it impose a constraint ?
$F_{BWall} = N_{BWall}$	Normal by wall	N1,N2, N3	NO	yes
F_{BYou}	Contact hand on wall	N1, N2, N3	NO	no
$F_{BE} = W_{BE}$	Weight of book, by earth	N1,N2,N3 and $F=GM_1m_2/R^2$	YES, Gravitational	no
$F_{BWall} = f_{Bwall}$	Friction by wall on book	N1, N2, N3	NO	yes
d)	Forces on ball	Obey a Force Law? No /yes (which one?)	Is a fundamental force?	Does it impose a constraint ?
F_{Blatch}	Contact by Latch on ball	N1,N2, N3	NO	no
$F_{BSpring}$	Elastic on ball	N1,N2,N3 and Hooke's law	NO	no
$F_{B\ lower\ Wall} = N_{B\ low\ wall}$	Normal force supporting ball from falling down thru barrel of gun	N1, N2, N3	NO	yes
$F_{B\ Upper\ Wall} = N_{B\ Up\ Wall}$	Normal force from top on ball keeping ball from moving upward	N1, N2, N3	NO	yes
$F_{BEarth} = W_B$	Weight of ball, by Earth	N1,N2,N3 and $F=GM_1m_2/R^2$	YES, gravitational	no
e)	Forces on ball	Obey a Force Law? No /yes (which one?)	Is a fundamental force?	Does it impose a constraint ?
$F_{BString} = T_{BString}$	Tension by string	N1,N2,N3	No	no

$F_{BString}=T_{BString}$	Tension by string	N1,N2,N3	No	no
$F_{BSpring}$	Elastic force by spring	N1,N2,N3 and Hooke's law $F_{BSpring}=-k\Delta x$	No	no
F_{BE}	Weight of ball, by Earth	N1,N2,N3 and $F=GM_1m_2/R^2$	Yes, Gravitational	no

Problem 3. Start this problem on a clean piece of paper; label the problem Prob#3.
A box of mass 50 kg is on an elevator that is slowing down with a constant acceleration of magnitude 1 m/s^2. When the elevator reaches the last floor it stops. The elevator alone is 1000kg. In order to get full credit you must:

- work out the problem with variables, (e.g., use m for the mass of the box, M for the mass of the elevator, etc).
- when you have reached the final answer you can replace the variables by the given numbers (m = 50 kg, etc. Use g = 10 m/s^2 in your calculations).
- use the proper units for your answers

a) Your goal is to determine all the forces exerted on the elevator as it is slowing down.

Please make sure to:

- include all the relevant free body diagrams that will help you to solve the problem. You must label the forces using double subscript notation.
- indicate the coordinate system that you will use in your mathematical representation
- make sense of your answer: check that the magnitude of the forces are consistent with your free body diagram and with the elevator's motion diagram (you must show the elevator's motion diagram)
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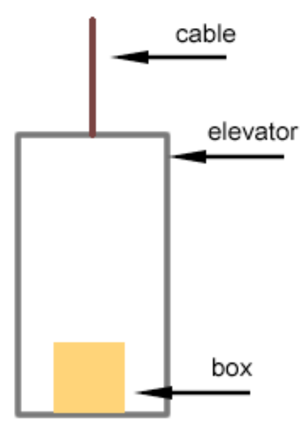


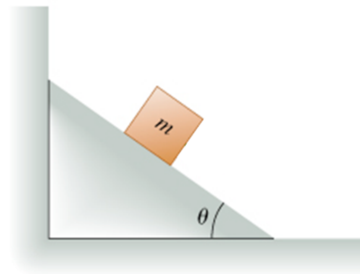
Answer: FORCE = ON ELEVATOR BY EACH INTERACTION

b) While the elevator is on the last floor and with the box still on it, its cable breaks. What are all the forces acting on the elevator now?

Answer: *assuming it is not already sitting on the ground, it will now be in free-fall (freely falling only under the influence of the Earth's pull) so it is accelerating at* ***g, and the result is that the normal force is reduced to ZERO… so there is only one force downward = Wt= Mg=1000N, down.***

Problem 4. See attached page

A box is moving up a smooth incline plane of angle α with respect to the horizontal. When it reaches a certain height it momentarily stops and then starts to slide down.



a) Draw the free body diagram of the box when it is **going up** the incline, when it **stops** and when it **starts to go down**. You must label the forces using double subscript notation.
b) Draw the box's **motion diagram** during the complete motion (going up and down).
c) Choose a convenient coordinate system to **calculate the net force** acting on the box during the complete motion (when the box is going up, it is at rest and it is going down).
d) Is the direction of the net force consistent with the motion diagram drawn in part b). State concisely the logic of your reasoning. *Use complete sentences, but you can use shorthand physic notation within the sentences*.
e) Describe in words another physical situation where an object has the same motion diagram as the box in this problem.

Problem 5 See attached page

A wedge with an inclination of angle θ rests next to a wall. A block of mass m is sliding down the plane, as shown. There is no friction between the wedge and the block or between the wedge and the horizontal surface.

a) Find the magnitude, F_{net}, of the sum of all forces acting on the block. [**answer:** $F_{net} = mg\sin\theta$]
b) Find the magnitude of the force that the wall exerts on the wedge **[answer** $F_{\text{wall on wedge}}=(1/2)mg\sin 2\theta$]

In your solution, make sure to:

- include **all the relevant** free body diagrams that will help you to solve the problem. You must label the forces using double subscript notation (on⇔by)
- indicate the **coordinate system(s)** that you will use in your mathematical representation of the problem.

Solution: