Lecture 13

Weds: Read 4.4 - 4.5

Fri: ~~HW 4 5pm~~ Next Monday HW 5pm

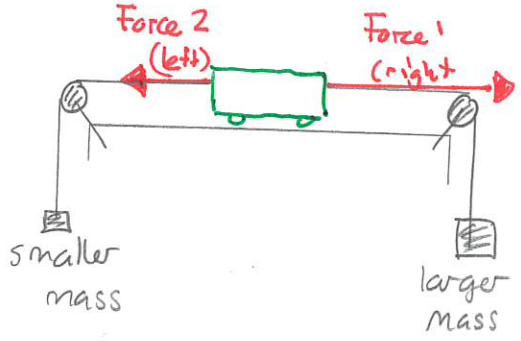
Forces and Motion: Multiple Forces.

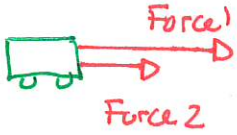
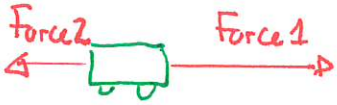
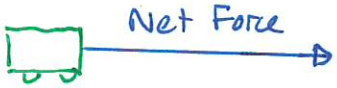
We have seen that, in general

Interactions between objects → Described via forces → Forces tend to produce acceleration

↳ Forces tend to change velocity

The first step to clarifying the word "tend" concerns situations where there are multiple forces. This is frequently the case. Consider the cart/track situation and suppose that there are two strings attached to different masses. Experiments would reveal that the resulting motion of the cart is the same as if there were a single net force acting on the cart. This net force would be obtained via:



	Forces pull in same direction	Forces pull in opposite directions
Actual		
Same as		
	net force = add two forces	net force = subtract forces

Newton's First Law

The Law of Inertia can be recast into the following:

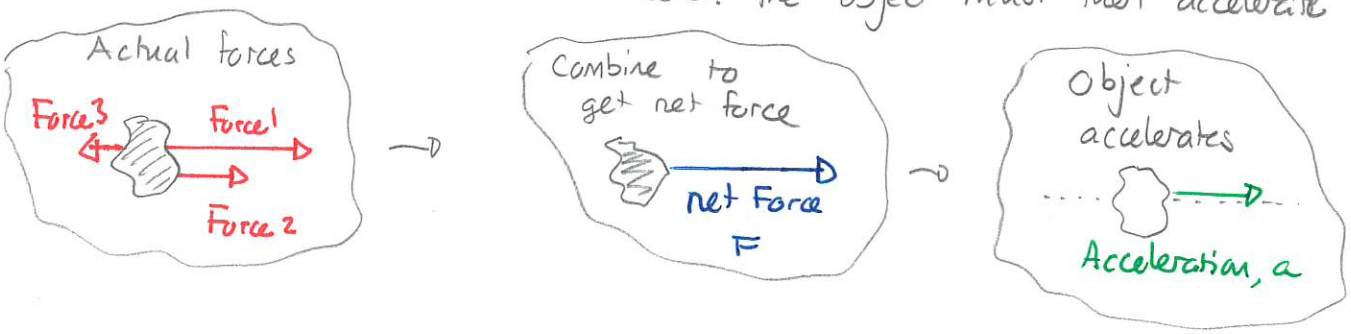
> The net force on an object is zero $\Leftrightarrow$ the acceleration of the object is zero $\Leftrightarrow$ velocity of the object is constant.

Quiz 1 70% - 90%

Quiz 2 30% - 30%

Newton's Second Law

In many situations the forces on an object will not cancel and the net force will not be zero. The object must then accelerate



The acceleration is related to the net force via Newton's Second Law

> Suppose that the net force on an object with mass m is F. Then the acceleration of the object is
>
> $$\text{acceleration} = \frac{\text{net force}}{\text{mass}} \quad \text{or} \quad a = F/m$$

Alternatively

> net force on object = mass of object × acceleration of object
>
> $$F = ma$$

This requires a way to measure the size of a force. In standard units:

mass $\rightsquigarrow$ kilogram = kg

acceleration $\rightsquigarrow$ meters/second^2 = M/S^2

force $\rightsquigarrow$ Newton = N

Concepts of Physics: Group Exercise 2

18 September 2023

Names: _____ _____ _____

_____ _____

1 Pulling and pushing objects

A 4.0 kg (about 9 lb) cart can move along a horizontal frictionless surface. Two people pull on horizontal ropes attached to opposite sides of the cart.

Suppose that the person on the left pulls with force 8.0 N and the person on the right pulls with force 20 N.

a) Determine the acceleration of the cart.

Suppose that the cart is initially at rest and that the two people constantly pull with the forces described above.

b) Determine the speed of the cart after 1.0 s.

c) Determine the speed of the cart after 2.0 s.

d) Determine the speed of the cart after 3.0 s.

e) Determine the speed of the cart after 4.0 s.

f) If the situation is such that the two people have to move along with the cart to keep the ropes tight, roughly how long will they be able to sustain this motion? To assist you, a world class sprinter can run 100 m in about 10 s.

g) Imagine that you were to push a 47 kg dog (medium/large size) on a 3 kg skateboard along a frictionless horizontal surface. You do so by exerting a 100 N horizontal force (roughly the same as needed to hold a 20 lb object at rest). Starting from rest roughly how long would you be able to sustain this motion?

h) Does is appear that moving ordinary-sized objects with constant acceleration for sustained periods is easy? Explain your answer.

Answer:

a) 

net force = 20N - 8.0N = 12 N

$$\text{acceleration} = \frac{\text{net force}}{\text{mass}} = \frac{12\text{N}}{4.0\text{kg}} = 3.0\text{m/s}^2$$

b) In the next parts

c)

d) change in speed = acceleration x time

e)

After 1s

change in speed = $3.0\text{m/s}^2 \times 1\text{s} = 3.0\text{m/s}$

After 2s

change in speed = $3.0\text{m/s}^2 \times 2\text{s} = 6.0\text{m/s}$

After 3s

change in speed = $3.0\text{m/s}^2 \times 3\text{s} = 9.0\text{m/s}$

After 4s

" " " = $3.0\text{m/s}^2 \times 4\text{s} = 12.0\text{m/s}$

So

time	speed
0s	0m/s
1s	3m/s
2s	6m/s
3s	9m/s
4s	12m/s

f) A world class sprinter does speed = $\frac{100\text{m}}{10\text{s}} = 10\text{m/s}$. In the situation above we would reach this in a little after (3.0s)

g) $\text{accel} = \frac{100\,N}{50\,kg} = 2\,m/s^2$

we would be able to sustain this until the speed reaches about 10 m/s.

This would take about 5 s.

h) No, based on the above the constant acceleration results in constantly increasing speed. In a short duration our speeds will be too fast to run.