Mon: HW due by 5pm

Ex 117, 120, 121, 123, 124, 125

Ch 4 Probs 38, 40

Forces and Motion

We aim to describe how interactions between objects affect the state of motion of an object of interest. The scheme is:

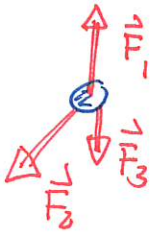
Identify object of interest

drop 

Identify other object that interacts with object of interest

Describe interaction via a force vector

List all forces on object



Compute net force

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$

The net force will determine

* acceleration of object
* how object's velocity changes

Quiz 1 80% - 95%

Newton's Second Law

If the net force on an object is not zero then, by Newton's First Law, it cannot have zero acceleration. In this case Newton's Second Law states

> Let $\vec{F}_1, \vec{F}_2, \ldots$ be all the forces acting on an object. Then the acceleration of the object is related to the forces via
>
> $$\vec{F}_{net} = m\vec{a}$$
>
> where
>
> $$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \cdots = \sum_{\text{all forces}} \vec{F}_i$$

Again note that forces relate to acceleration and not velocity. Also

> The direction of the net force vector is the same as the direction of the acceleration vector.

Quiz 2 80% ~ 95%

Quiz 3 80% - 95%

Quiz 4 60%

DEMO: Hoop / ball demo.

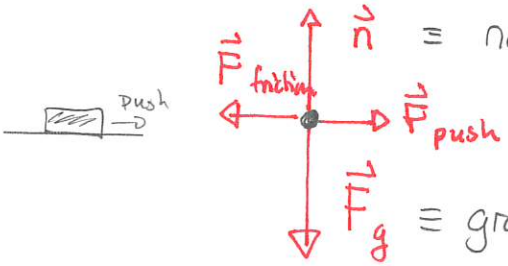
Free body diagrams

In general we have many forces acting on an object. We list these using a free-body diagram which consists of

a) a dot for the object

b) a vector for each force

Example Consider a book pushed at constant speed along a horizontal surface. The push is horizontal. Then a free-body diagram is



$\vec{n}$ ≡ normal force exerted by surface (perpendicular to surface)

$\vec{F}_g$ ≡ gravitational force exerted by Earth

Newton's Second Law and Motion

Newton's Second Law allows one to connect forces to motion. The key will be to use acceleration which emerges from Newton's Second Law.

122 Force, acceleration and velocity

The exercise will investigate the assertion:

"The larger the force on an object, the larger the object's velocity."

Consider two carts, labeled A and B, each with mass 3.0 kg that can slide left or right. The net force on cart A is 12.0 N to the right and the net force on cart B is 6.0 N to the right. It would appear that the velocity of A is twice the velocity of B. Consider the situation where the velocity of each cart at 0.0 s is exactly 0.0 m/s and that the forces act on the carts at all later times. Explain your answers in the following. *(111F2023)*

a) Determine the velocity of each cart at 1.0 s, 2.0 s, 3.0 s, 4.0 s and 5.0 s.

b) Is the "velocity of A twice the velocity of B?"

c) Is the "velocity of A at 2.0 s twice the velocity of B at 4.0 s?" Does this suggest a need to be specific with statements about velocity?

Now consider a different situation where the velocity of A at 0.0 s is exactly −8.0 m/s and the velocity of B is 0 m/s.

d) Determine the velocity of each cart at 1.0 s, 2.0 s, 3.0 s, 4.0 s and 5.0 s.

e) Is the "velocity of A twice the velocity of B?"

f) Is the "velocity of A at 3.0 s twice the velocity of B at 3.0 s?"

g) Is the statement: "The larger the force on an object, the larger the object's velocity" true or not in general?

a) $V_f = V_i + a\Delta t$ means we need acceleration. This comes via

$F_{net} = ma$

CART A

$12.0N = 3.0kg\ a$

$\Rightarrow a = 4.0 m/s^2$

This

t	V
0s	0m/s
1s	4m/s
2s	8m/s
3s	12m/s
4s	16m/s
5s	20m/s

CART B

$6.0N = 3.0kg\ a$

$\Rightarrow a = 2.0 m/s^2$

t	V
0s	0m/s
1s	2m/s
2s	4m/s
3s	6m/s
4s	8m/s
5s	10m/s

b) In general NO. Only if we compare at the same times YES,

c) No they are the same at these times. If we compare we need to specify the times for each.

d)

CART A		CART B	
t	v	t	v
0s	−8m/s	0s	0m/s
1s	−4m/s	1s	2m/s
2s	0m/s	2s	4m/s
3s	4m/s	3s	6m/s
4s	12m/s	4s	8m/s
5s	16m/s	5s	10m/s

e) Not at any instant

f) No

g) No the previous answer gives a contradiction

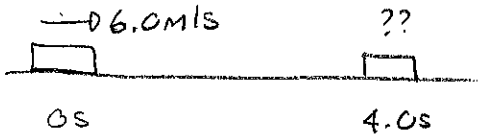
141 Sledding dog

A 37.0 kg dog sits on a 3.0 kg sled that can slide along a horizontal frictionless sheet of ice. At one instant the dog and sled are moving right with speed 6.0 m/s. For the next 4.0 s a person exerts a constant 80 N force on the dog/sled in the same direction as they move. *(111F2023)*

a) Determine the velocity of the dog/sled at the end of the 4.0 s period.

b) Determine the distance traveled by the dog/sled during the 4.0 s period.

Answers: a)



$t_i = 0s$ $t_f = 4s$

$x_i = 0m$ $x_f =$

$v_i = 6m/s$ $v_f =$

Need acceleration

$F_{net} = ma \Rightarrow 80N = 40kg\ a \Rightarrow a = 0.5 m/s^2$

Then kinematics

$v_f = v_i + a\Delta t \Rightarrow v_f = 6.0m/s + 0.50m/s^2 \times 4.0s$

$v_f = 8.0m/s$

b) $x_f = x_i + v_i\Delta t + \frac{1}{2} a (\Delta t)^2$

$x_f = 0m + 6.0m/s \times 4.0s + \frac{1}{2} 0.5m/s^2 (4.0s)^2$

$= 24m + 4m$

$x_f = 28m$