Phys 131 2024

Lecture 14

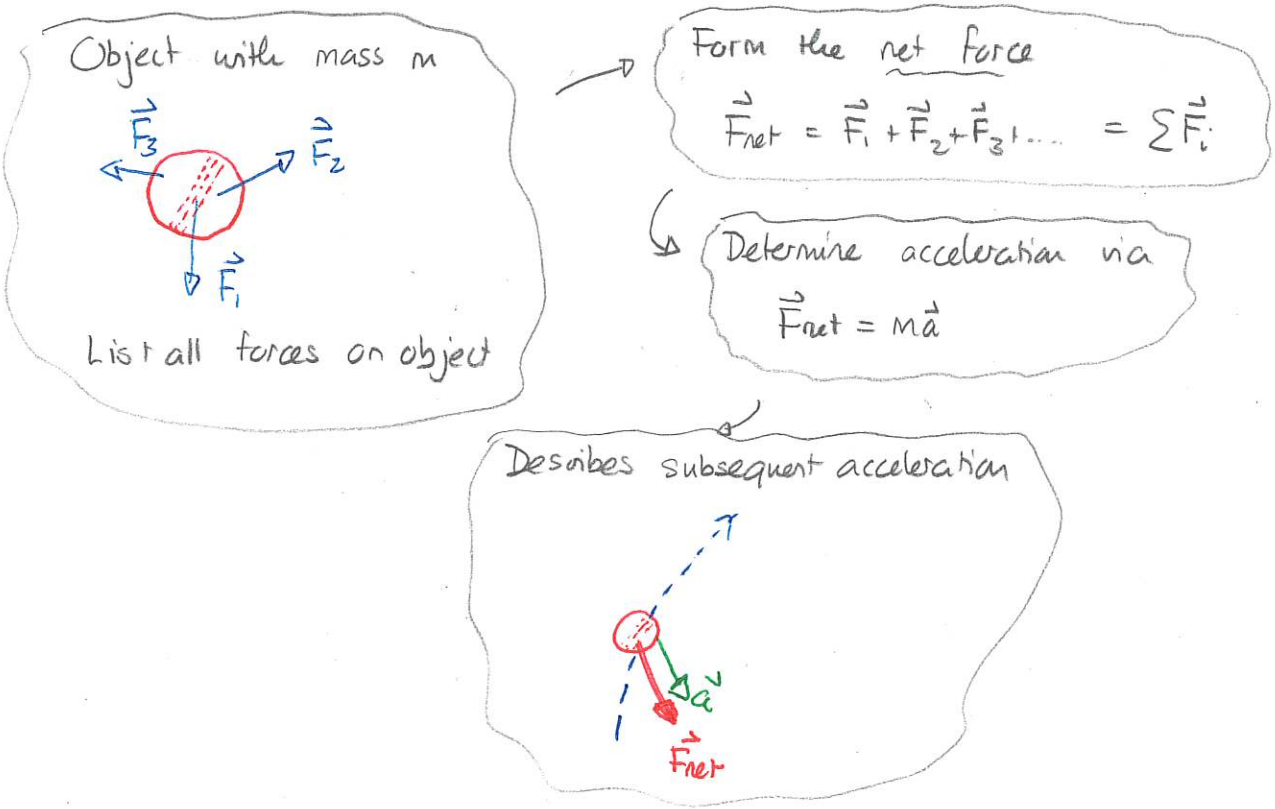
Mon: Warm Up 6 D2L

Tues: Discussion/quiz

Ex: 139, 140, 144, 149, 152, 153, 160, 164

Newton's Second Law

Newton's second law relates the forces on an object to the acceleration of the object, thereby connecting forces to motion.



Note that this involves vectors. What the scheme says is

* get components of individual forces $F_{1x}, F_{1y}, F_{2x}, F_{2y} \ldots$
* form $F_{net\,x} = F_{1x} + F_{2x} + F_{3x}$ $\quad F_{net\,y} = F_{1y} + F_{2y} + F_{3y}$
* set $F_{net\,x} = ma_x$ $\quad F_{net\,y} = ma_y$

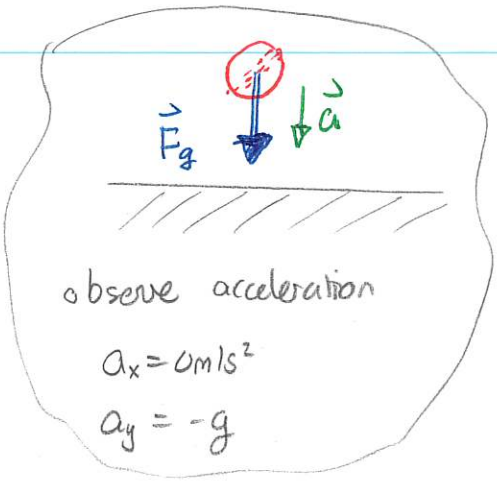
$\Rightarrow$ $\boxed{\sum F_{ix} = ma_x \qquad \sum F_{iy} = ma_y}$ $\rightarrow$ algebra eventually gives answers.

To make this work, we need to describe some common forces

1) Gravitational force

(near Earth's surface)

Earth exerts a gravitational force on any object. Near Earth's surface



If no other forces are present then:

$$\sum F_{ix} = ma_x \Rightarrow F_{gx} = 0$$

$$\sum F_{iy} = ma_y \Rightarrow F_{gy} = -mg$$

Thus:

Earth always exerts a gravitational force on any object with non-zero mass.

For an object with mass m

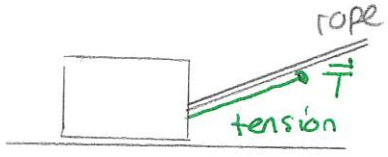
1) $\vec{F}_g$ is vertically down (to center of Earth)
2) $\vec{F}_g$ has magnitude $F_g = mg$ ← positive

Notes: 1) "F_g" is not "g"

2) the gravitational force is always present and cannot be turned off
3) the gravitational force only depends on the objects mass and not its state of motion
4) the gravitational force is sometimes called weight, $\vec{W}$.

Tension

Ropes, cables, wires, etc,... can all exert forces along their direction of pull. These are called tension forces. There is no general rule for predicting tension forces and they have to be provided or else inferred from the objects motion.

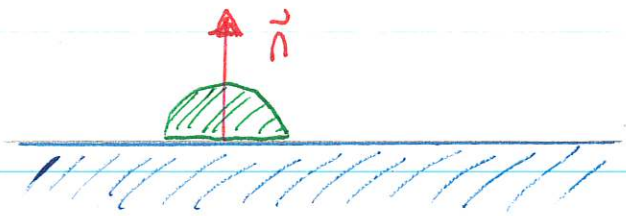


Quiz 1 40% – 80%

Quiz 2 40% – 70%

Quiz 3 DEMO – Scale / rope / mass

Normal force



Normal forces arise from the interaction between the surfaces of two objects. These result from microscopic interactions between the atomic matter in the materials. In general there is no rule to predict the normal force. However

> When two objects are in contact each exerts a normal force on the other. The normal force, $\vec{n}$, exerted by any object satisfies:
>
> 1) it is perpendicular to the contact surface.
> 2) its magnitude adjusts according to the circumstances.

Quiz 4 60% – 90%

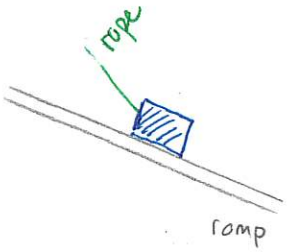
Quiz 5 70% – 90%

Free body diagrams

We need to list all the forces that act on an object of interest. This is done using a free-body diagram consisting of:

* a dot representing the object
* one vector for each force – tail of vector on dot

Consider a block lowered down a ramp



148 Lowering a bunch of bananas

A bunch of bananas has mass 40 kg. Starting from rest, they are lowered from a ship by a rope through a distance of 12.0 m. The rope pulls vertically upward with tension 305 N and there is an upward air resistance force of 60 N. Determine the time taken to lower the bananas. *(131F2024)*

Answer:

Strategy

Newtons 2nd Law gives acceleration. → Kinematics gives time

Newton's 2nd Law

① FBD

② Newton's 2nd Law $\Sigma F_{ix} = ma_x$

$\Sigma F_{iy} = ma_y$

No horizontal motion $\Rightarrow a_x = 0$

③ $\Sigma F_{iy} = ma_y \Rightarrow T + F_{air} - F_g = ma_y$

$\Rightarrow 305N + 60N - mg = ma_y$

$\Rightarrow 365N - 40kg \times 9.8m/s^2 = 40kg\, a_y$

$\Rightarrow -27N = 40kg\, a_y$

$\Rightarrow a_y = -0.675m/s^2$

Kinematics:

$t_i = 0s \quad t_f = ?$

$y_i = 12.0m \quad y_f = 0m$

$v_{iy} = 0m/s \quad v_{yf} = ?$

$a_y = -0.675m/s^2$

$y_f = y_i + v_{iy}\Delta t + \frac{1}{2} a_y \Delta t^2$

$\Rightarrow 0m = 12.0m + \frac{1}{2}(-0.675m/s^2)\Delta t^2$

$\Rightarrow -12m = -0.3375m/s^2\, \Delta t^2$

$\Rightarrow \Delta t = \sqrt{\frac{12m}{0.3375m/s^2}} \Rightarrow \Delta t = 5.96s$