DYNAMICS

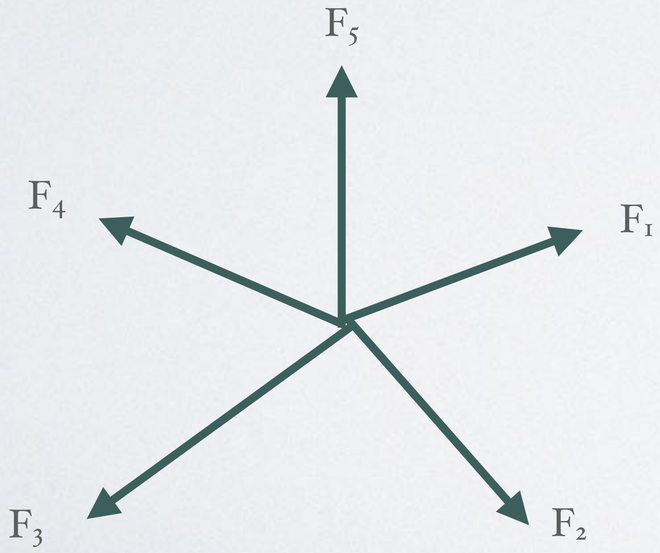
Chapter 4

FORCES

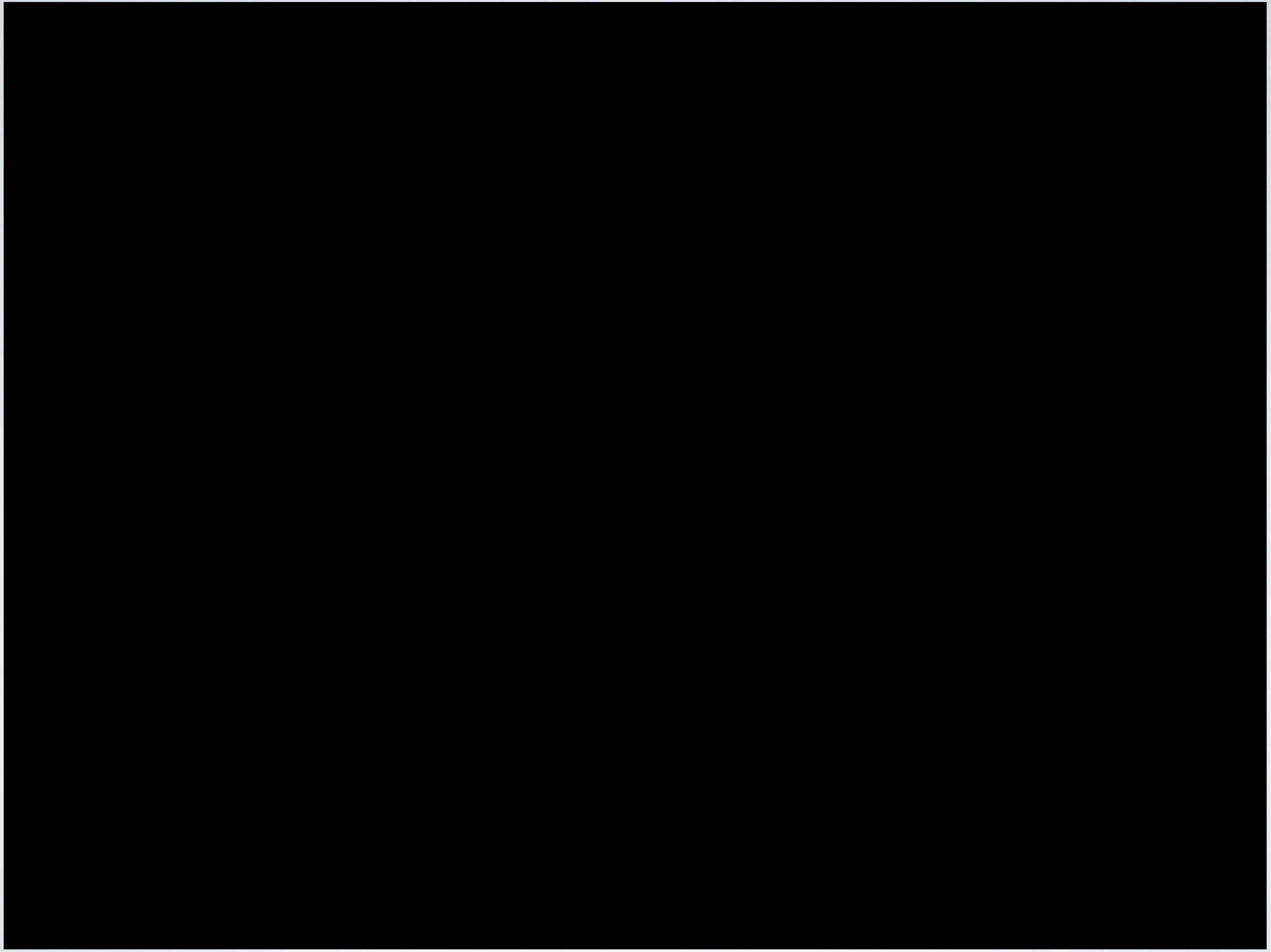
- Dynamics is the study of why things move, as opposed to kinematics which just describes their motion.
- We will see that dynamics is the study of forces. There are many types of forces but we can start with the forces exerted by people where we can push or pull things.
- We can see that forces are vectors, we can push things with a greater or lessor magnitude and we can push things in different directions.
- Forces add like all vectors, if 2 people pull in the same direction the forces will add, if 2 people push in opposite directions they will tend to cancel, and if they push at some other direction you must add them as components.

FREE BODY DIAGRAM

- Drawing the forces on an object is called a free body diagram.
- This is a way to visually picture what the net force on a object will be.



The free body diagram is a visual aid, to calculate the force vector use components



NEWTON'S LAWS

- Newton suggested 3 laws of motion to describe why objects move

1. Objects in motion stay in motion and objects at rest stay at rest unless acted upon by an outside force.

2. A net force causes an object to accelerate inversely proportional to its mass.

$$\sum \vec{F} = m\vec{a}$$

3. Every force has an equal an opposite force.

$$\vec{F}_{ab} = -\vec{F}_{ba}$$

THE UNIT OF FORCE

- The MKS unit of force is called the Newton and is equal to a kg m / s^2.
- This makes sense since F = ma, and the units of m × a are kg × m/s^2.
- We will use N as the symbol for Newtons.

EXAMPLE 4.1

- **What Acceleration Can a Person Produce when Pushing a Lawn Mower?** Suppose that the net external force (push minus friction) exerted on a lawn mower is 51 N (about 11 lb) parallel to the ground. The mass of the mower is 24 kg. What is its acceleration?

$$F_{net} = ma \qquad a = \frac{F_{net}}{m} \qquad = \frac{51N}{24kg} = 2.1m/s^2$$

EXAMPLE 4.2

- **What Rocket Thrust Accelerates This Sled?** Prior to space flights carrying astronauts, rocket sleds were used to test aircraft, missile equipment, and physiological effects on human subjects at high speeds. They consisted of a platform that was mounted on one or two rails and propelled by several rockets. Calculate the magnitude of force exerted by each rocket, called its thrust **T** for the four-rocket propulsion system shown in the Figure. The sled's initial acceleration is 49 m/s^2 the mass of the system is 2100 kg, and the force of friction opposing the motion is known to be 650 N.

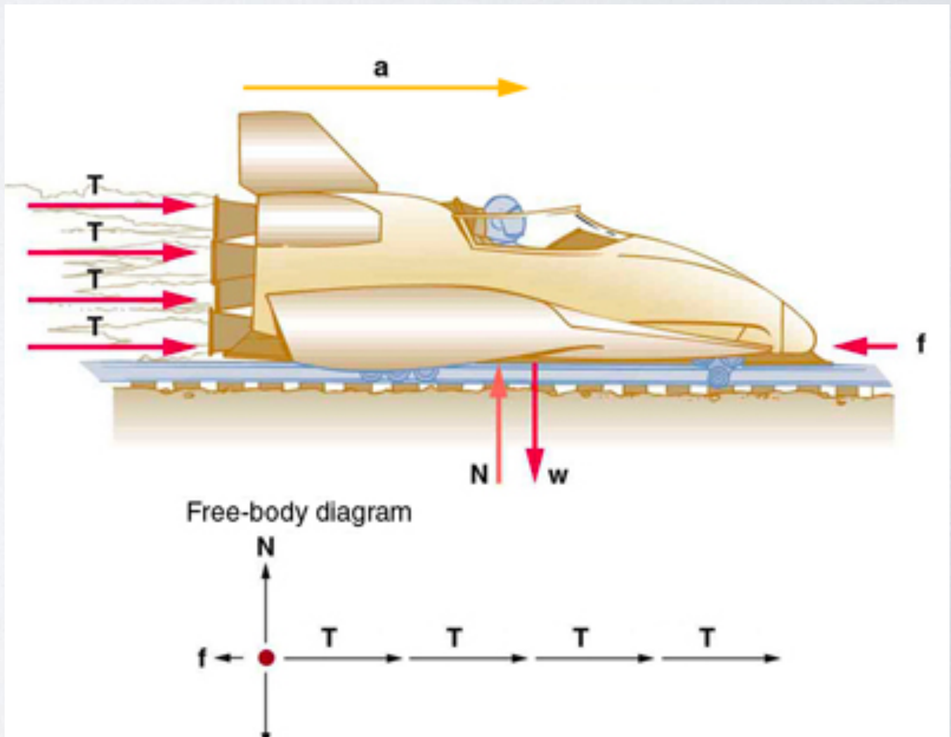
a = 49 m/s^2 T = ?

m = 2100 kg $F_{net} = ma$

F_{fr} = 650 N $4T - F_{fr} = ma$

$$T = \frac{1}{4}(F_{fr} + ma)$$

$$= \frac{1}{4}(650N + (2100kg)(49m/s^2) = 2.6 \times 10^4 N$$



WEIGHT

- What is weight? We use the term all the time, but what to we really mean by it.

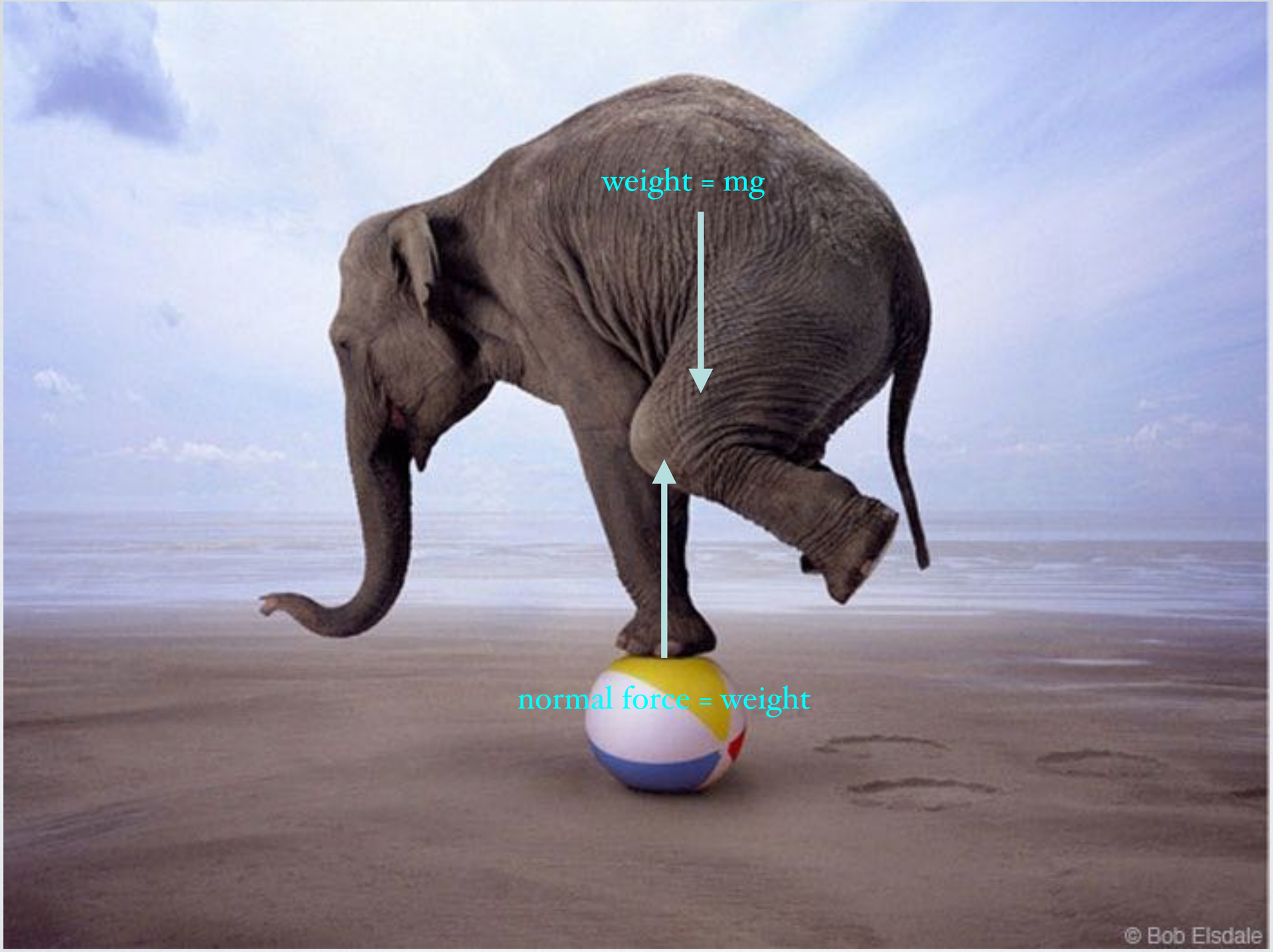
- Weight can be measured with a scale. If you stand on the scale your weight pushes down on it moving the arrow on a scale for an analog display.

- So weight is a force. It is your mass times the acceleration of gravity.

$$\vec{F}_w = m\vec{g}$$

NORMAL FORCE

- When you stand on the floor, does your weight cause you to accelerate downward?
- If not then there must be a force that balances your weight.
- We call this force the normal force, it is the force due to the structure of a material that pushes back on your weight.
- There is no formal for the normal force, it is whatever is needed to keep other forces from breaking through a surface.


weight = mg
normal force = weight
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Empire Strikes Back

We can look in Wookiepedia to find that the X-wing fighter is 12.5 meters long, but unfortunately its mass is not given.

Following XKCD we can scale a F-22 fighter jet which is 19m long and has a mass of 19,700kg to give the X-wing fighter a mass of (12.5/19) (19700) = 12,960kg

So the weight of the X-wing fighter is mg = (12960kg)(9.81m/s2) = 127, 138 N

So Yoda using the Force can exert a force of roughly ~130,00 N.

EXAMPLE 4.5

- **Weight on an Incline, a Two-Dimensional Problem**.
  Consider the skier on a slope shown in the Figure. Her mass including equipment is 60.0 kg. (a) What is her acceleration if friction is negligible? (b) What is her acceleration if friction is known to be 45.0 N?

m = 60.0 kg

θ = 90 - 25 = 65

a_x = ?

F_{fr} = 45.0 N

$$W_x = mg\cos\theta$$

$$W_y = mg\sin\theta$$

$$F_{net} = ma$$

a)

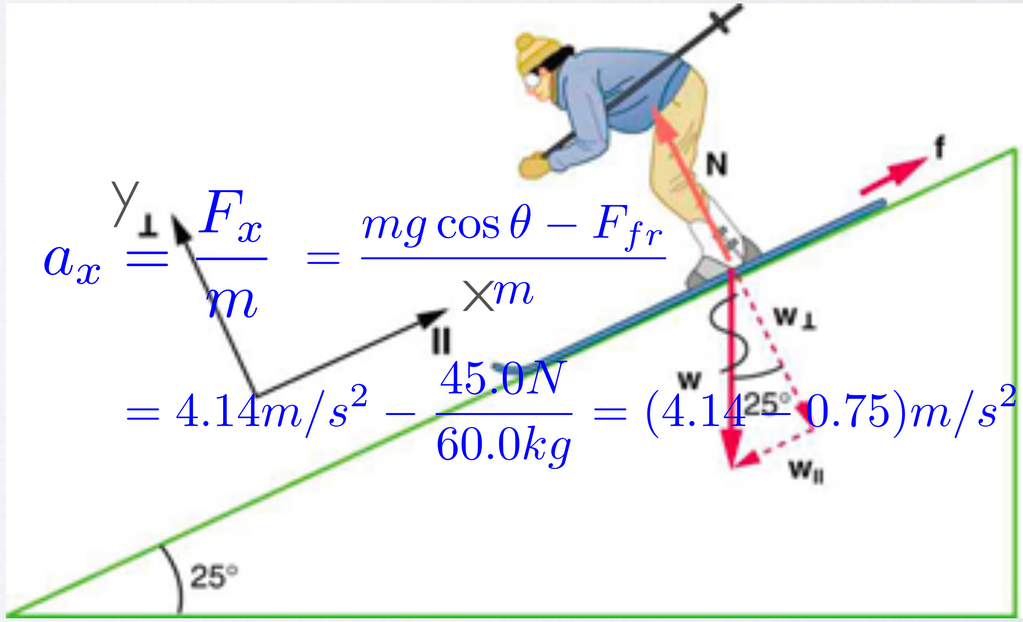
$$a_x = \frac{F_x}{m} = \frac{mg\cos\theta}{m}$$

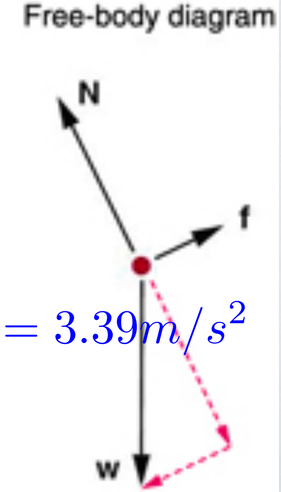
$$= g\cos\theta = (9.81 m/s^2)\cos 65 = 4.14 m/s^2$$

b)

$$a_x = \frac{F_x}{m} = \frac{mg\cos\theta - F_{fr}}{m}$$

$$= 4.14 m/s^2 - \frac{45.0N}{60.0kg} = (4.14 - 0.75) m/s^2 = 3.39 m/s^2$$





HOME WORK

- Chap 4 - 3, 7, 17, 25, 33, 34