
ENERGY

Energy is a scalar

Energy is conserved

- Cannot be created or destroyed, just shuffled around

Unit for energy is a joule (J)

- 1 J = 1 Nm

WORK

In physics, work (symbol W) is the energy needed to enact a force through some displacement

More of a pain to walk to the 2nd floor than the 3rd floor

$W = F_{||} D$

Only the force parallel to displacement does work

$$W = Fd\cos\theta$$

I.e. You apply 50 N of force horizontally as you move a grocery cart 30 m

- W = 50 N x 30 m = 1500 J

Assume force is *constant*

A force can be exerted on an object and do no work

WHICH OF THESE DOES WORK?

A. Holding a bag of groceries
B. A large asteroid drifts 20 km at a constant speed
C. Lifting a mug of hot chocolate to your mouth
D. Gravity on a couch as you push it across the room

WHICH OF THESE DOES WORK?

A. Holding a bag of groceries
B. A large asteroid drifts 20 km at a constant speed
C. **Lifting a mug of hot chocolate to your mouth**
D. Gravity on a couch as you push it across the room

BE SPECIFIC!

Is work done *by* an object or work done *on* an object?

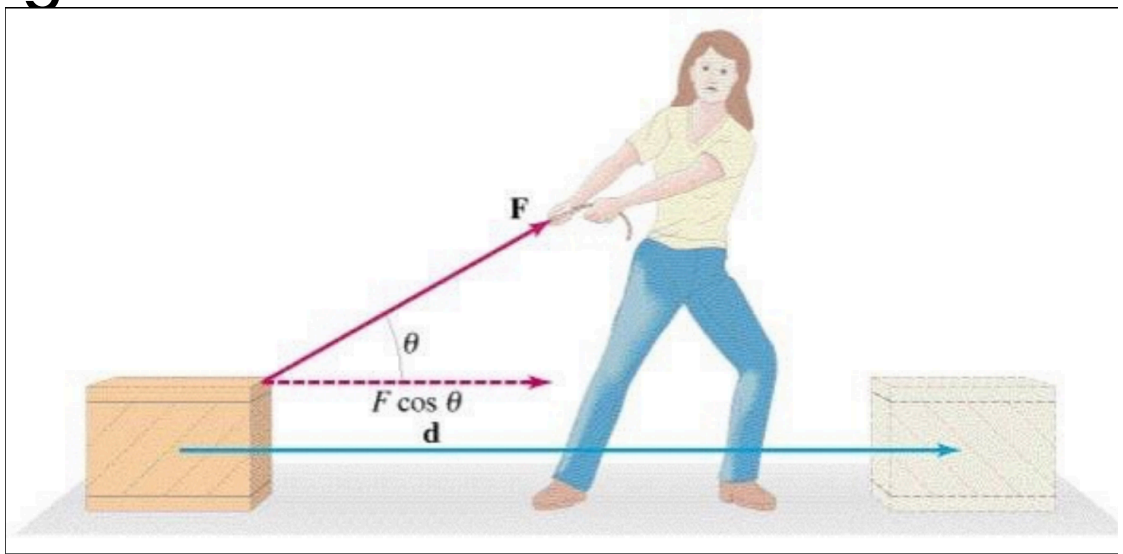
Is the work done by a *particular force* or work done by the *net force*?

You're off to college, and you want to take your entire manga collection.

You drag the 50 kg crate 40 m across the quad of your new campus, applying a constant applied force F_{app} =100N at an angle of 37° from the horizontal. The ground exerts a friction force

f = 50N.

- Determine the work done by each force acting on the crate and the net work done on the crate.
- Wg = 0,
- Wn = 0,
- Wapp = 100N cos 37x40m = 3200J
- Wfr = -50N x 40 m = -2000 J
- Wnet = 1200J



NEGATIVE ENERGY

Wait, why is friction's work negative?

Forces against motion do negative work

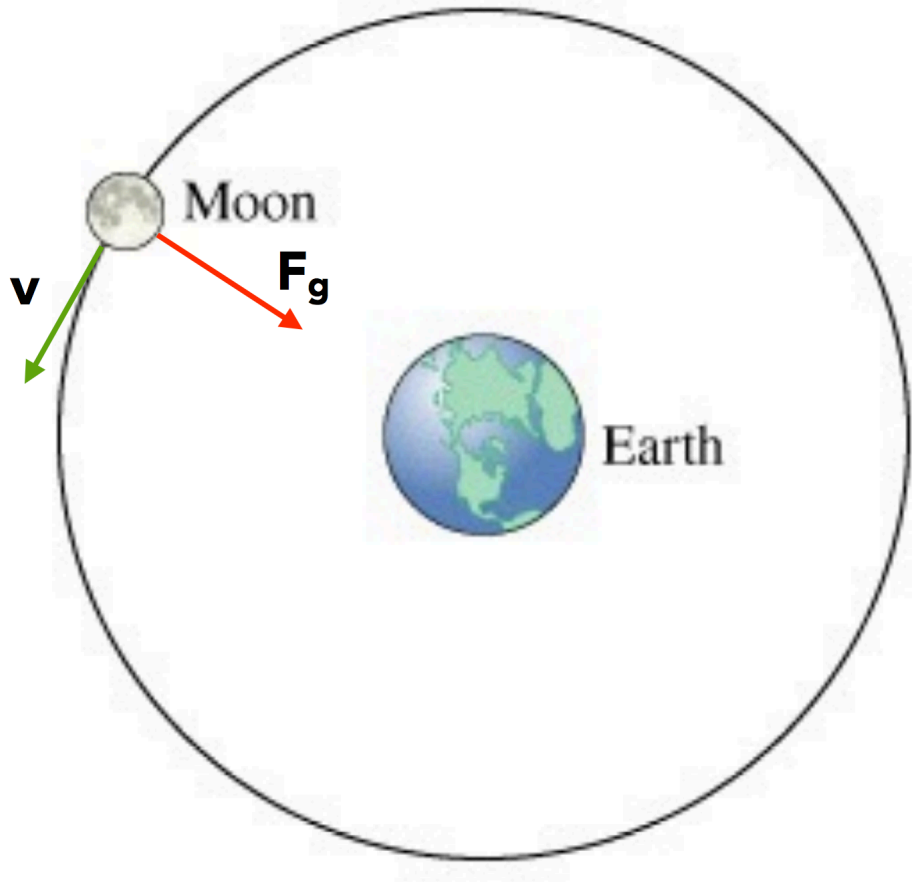
Energy put into the system is positive, energy taken out of the system is negative

THE MOON REVOLVES AROUND THE EARTH IN A CIRCULAR ORBIT, KEPT THERE BY THE GRAVITATIONAL FORCE EXERTED BY THE EARTH. WHAT WORK DOES GRAVITY DO ON THE MOON?

A. Positive work

B. Negative work

C. No work at all

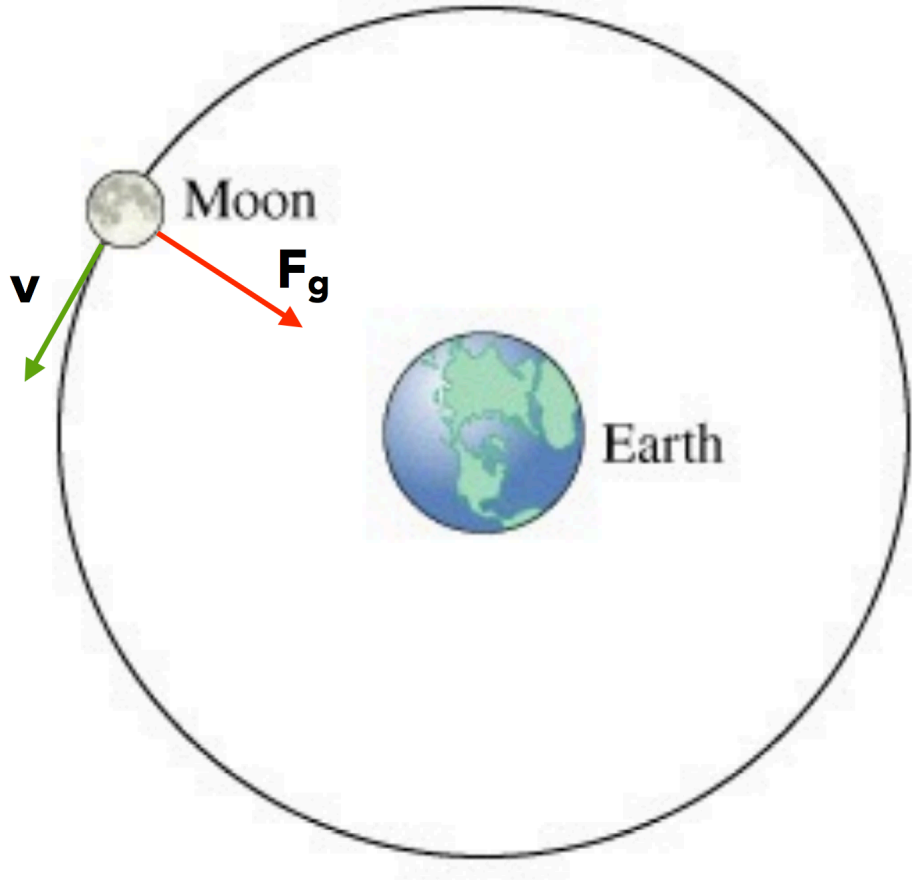


THE MOON REVOLVES AROUND THE EARTH IN A CIRCULAR ORBIT, KEPT THERE BY THE GRAVITATIONAL FORCE EXERTED BY THE EARTH. WHAT WORK DOES GRAVITY DO ON THE MOON?

A. Positive work

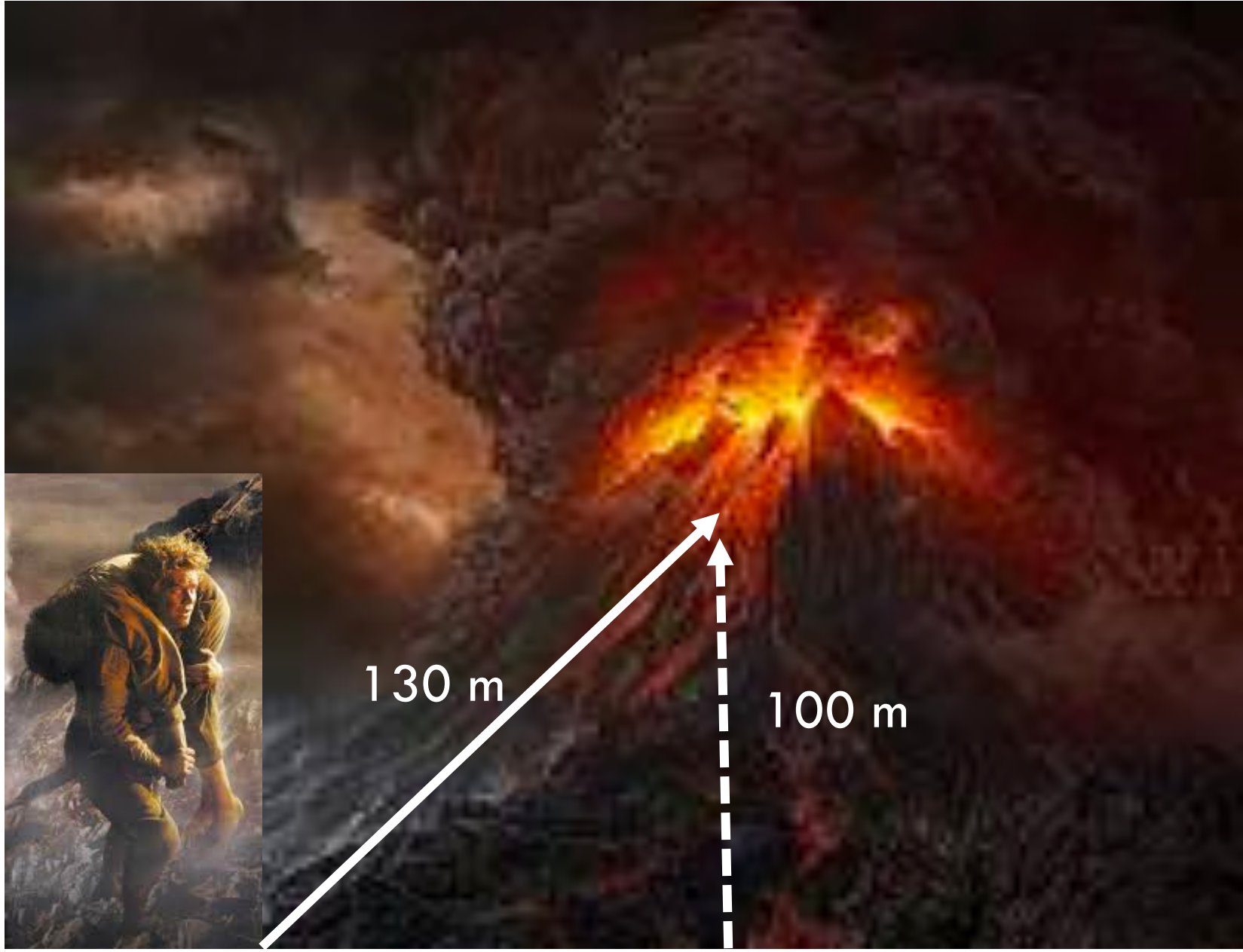
B. Negative work

C. **No work at all**



How much work does Sam do on Frodo (mass 50 kg) to carry him up the 100 m tall slope of Mt. Doom, over a total distance of 130 m?

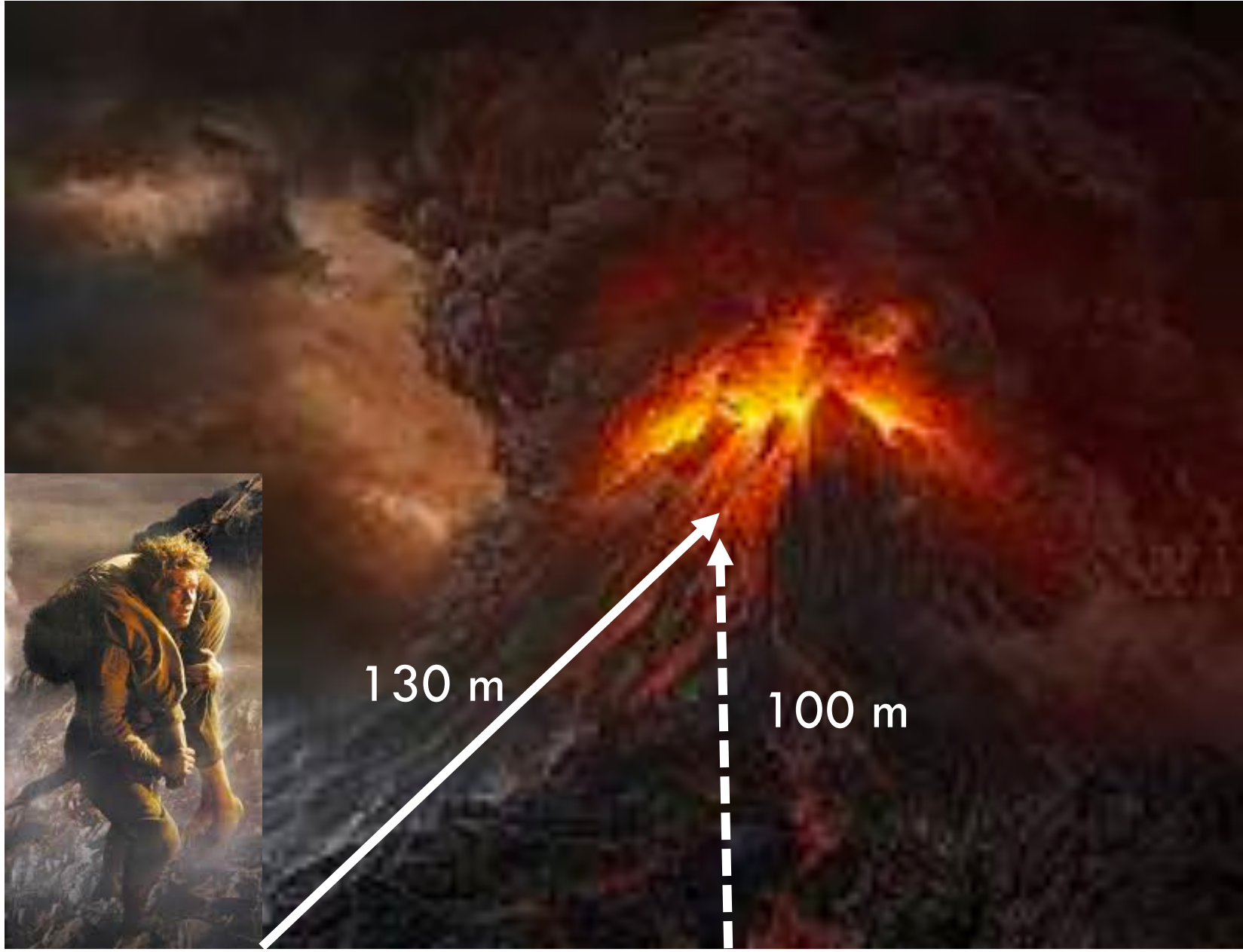
W_{sam} = 50 kg x 9.8 m/s^2 x 100m = 49,000 J



How much work does gravity do on Frodo?

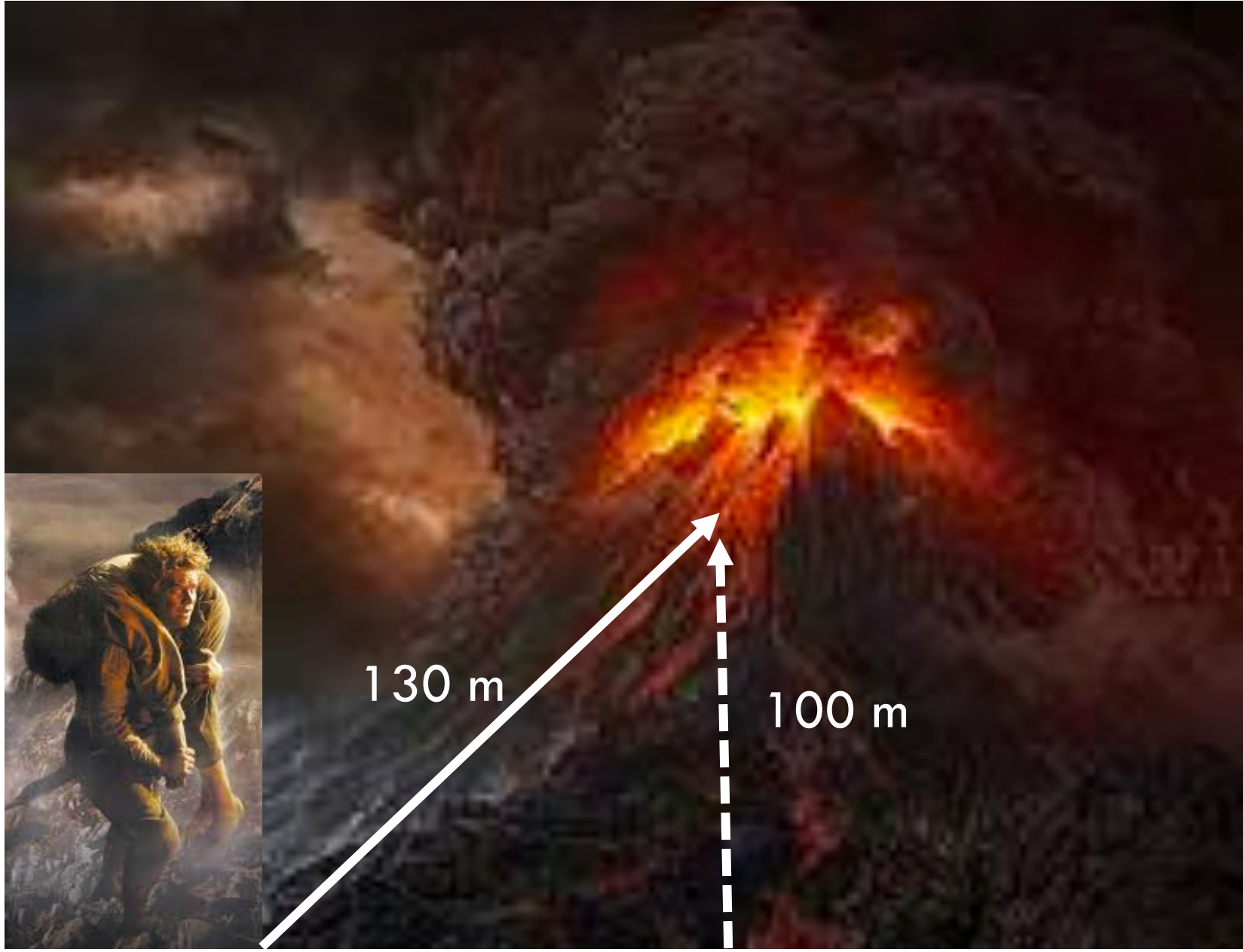
W_G=-(50 kg x 9.8 m/s^2) x 100 m

=-49,000J



What is the net work done on Frodo?

0 J



WORK AND VARYING FORCES

I.e. Spring when stretched or compressed

For unevenly applied forces, can use graph to find work!

FORCE VS. DISPLACEMENT GRAPHS

$W_{fr} = -2000\ J$, $W_{net} = 1200J$

3RD WAY TO CALCULATE WORK

You decelerate your car of mass 1000 kg from a velocity of 30 m/s to 10 m/s.

What is the work done on the car by the brakes?

$W = \Delta KE$

KINETIC ENERGY (KE)

Energy is the ability to do work

A bowling ball exerts a force on a pin and moves it a distance

- The bowling ball did work, thus has energy
- Kinetic energy is **energy of motion**

$$KE = \frac{1}{2} m v^2$$

Translational kinetic energy

- ”Translational” distinguishes from “rotational”

WORK - ENERGY THEOREM

Net work is equal to the change in kinetic energy

You decelerate your car of mass 1000 kg from a velocity of 30 m/s to 10 m/s.

What is the net work done on the car?

$$W_{net} = \Delta KE$$

$$W_{net} = \frac{1}{2}\, mv_f^2 - \frac{1}{2}\, mv_i^2$$

$$W_{net} = (1/2) \times 1000kg \times (10m/s)^2 - (1/2) \times 1000kg \times (30\ m/s)^2$$

$$W_{net} = -4 \times 10^5\ J$$

AN OBJECT INITIALLY HAS ENERGY KE. IF ITS MASS IS HALVED, WHAT HAPPENS TO ITS KINETIC ENERGY?

A. Halved
B. Quartered
C. Stays the same
D. Doubled
E. Quadrupled

AN OBJECT INITIALLY HAS ENERGY KE. IF ITS MASS IS HALVED, WHAT HAPPENS TO ITS KINETIC ENERGY?

A. **Halved**

B. Quartered

C. Stays the same

D. Doubled

E. Quadrupled

AN OBJECT INITIALLY HAS ENERGY KE. IF ITS VELOCITY IS DOUBLED, WHAT HAPPENS TO ITS KINETIC ENERGY?

A. Halved

B. Quartered

C. Stays the same

D. Doubled

E. Quadrupled

AN OBJECT INITIALLY HAS ENERGY KE. IF ITS VELOCITY IS DOUBLED, WHAT HAPPENS TO ITS KINETIC ENERGY?

A. Halved

B. Quartered

C. Stays the same

D. Doubled

E. **Quadrupled**

-If traveling at 60 km/hr, your car can brake to a stop within a distance of 20 m.

-One morning you're running late for school, flying down the road at 120 km/hr, and you come up to a stop light.

-Prove that the braking distance is 80 m. (The maximum braking force is approximately independent of speed)