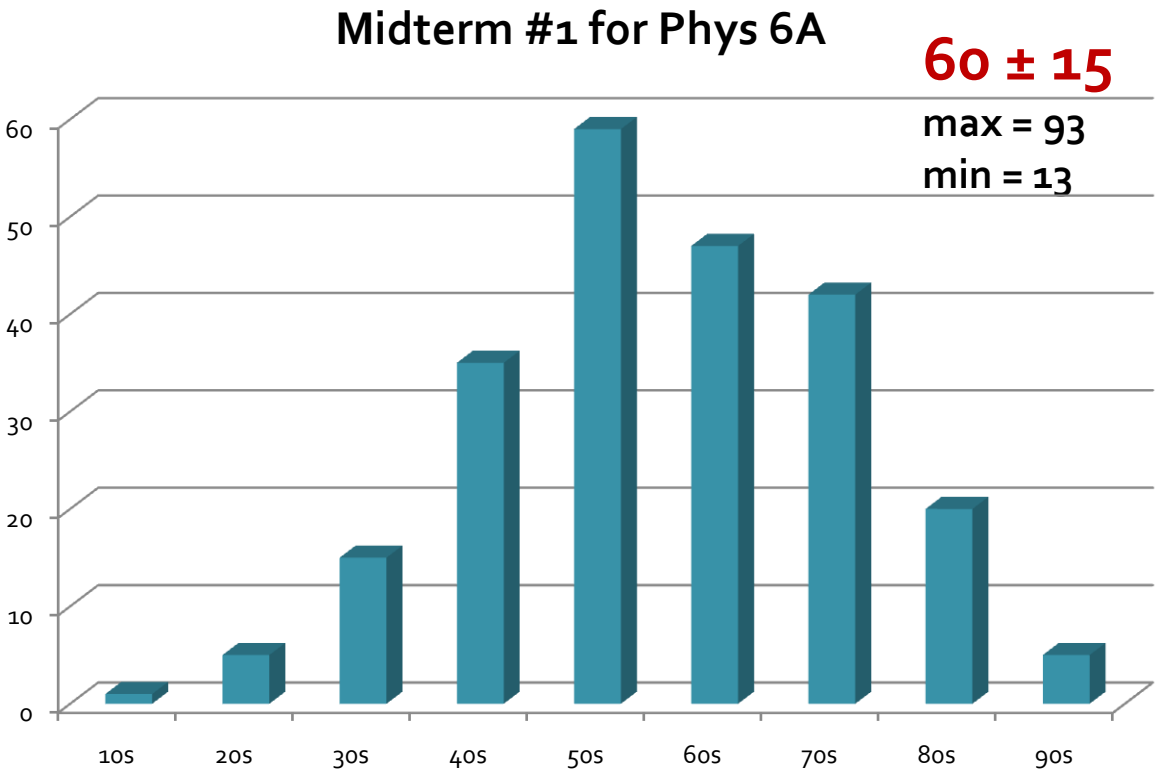
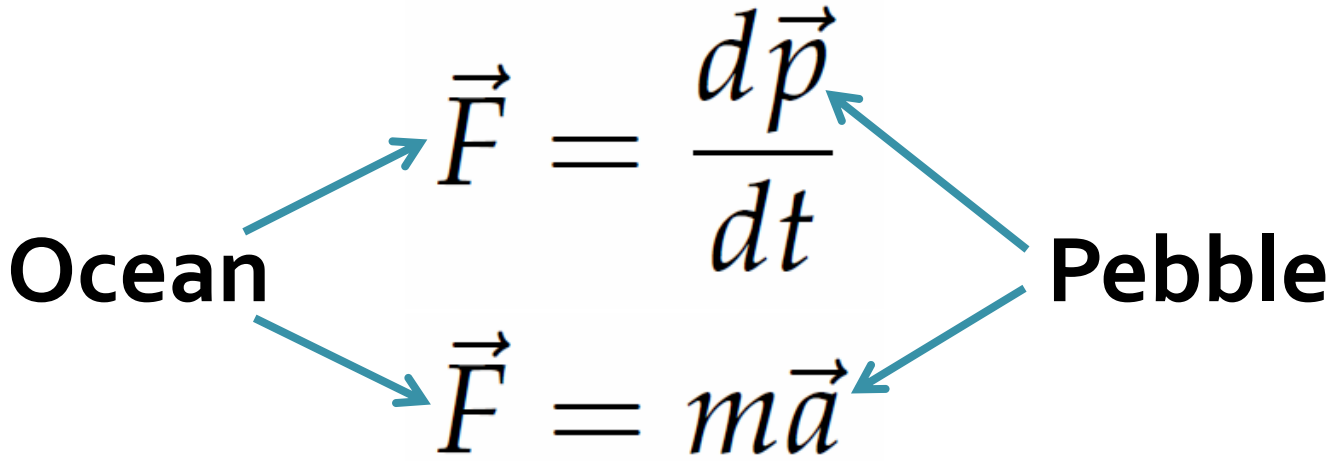


+10 points offset will probably be applied

Newton's memorable words

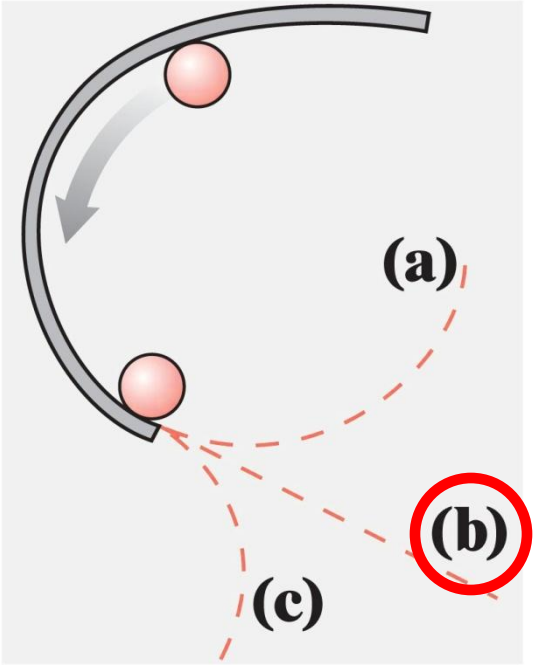
- If I have seen further than others, it is by standing upon the shoulders of giants.
- I was like a boy playing on the sea-shore, and diverting myself now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

Newton's 2nd Law – pebble and ocean?!



- For us, human, all too human, beings, pebbles provide our links toward the "truth."
- Experimental observables ("pebbles") are of more fundamental importance than theories ("ocean") in science.
- Science is exact, objective, and falsifiable because of experimental observables

- On a **horizontal** tabletop is a curved barrier that exerts a force on a ball, guiding its motion in a circular path as shown. After the ball leaves the barrier, which of the dashed paths shown does it follow?



Inertial Reference Frame

- Definition: A reference frame in which Newton's 2nd law is valid
- If a reference frame A is an IRF, then a reference frame B is an IRF if B is moving at a constant velocity relative to A. Why? Because from **F** = m**a** (bold face means a vector) **a** does not change when velocity is shifted by a constant amount.

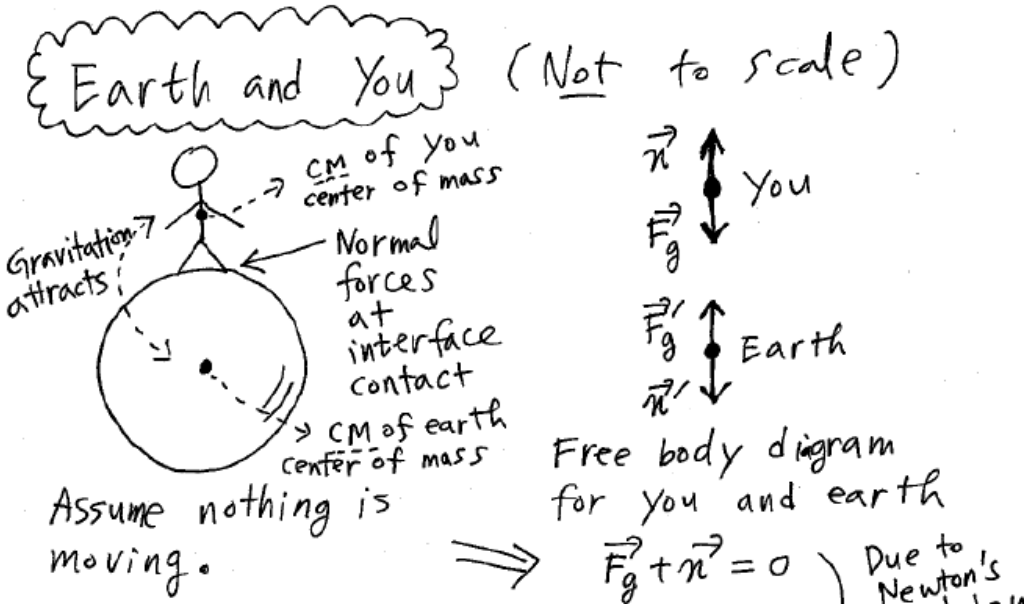
Newton's 3rd Law

- Forces come in pairs. ("3rd law pairs", "interaction pairs")
  - If object A exerts a force on object B, then object B exerts an oppositely directed force of equal magnitude on A.
  - Obsolete, but catchy language: "For every action there is an equal but opposite reaction."
  - Important points: The two forces always act on *different* objects; The two forces have the same nature (gravitational or otherwise); They are always equal in magnitudes and opposite in directions.

- **Clicker Q: (Newton's 3rd law) An object is put on earth and the earth is exerting gravity. Also, a normal force is acting from the earth to the object due to contact. Are these two forces a Newton's 3rd law pair?**

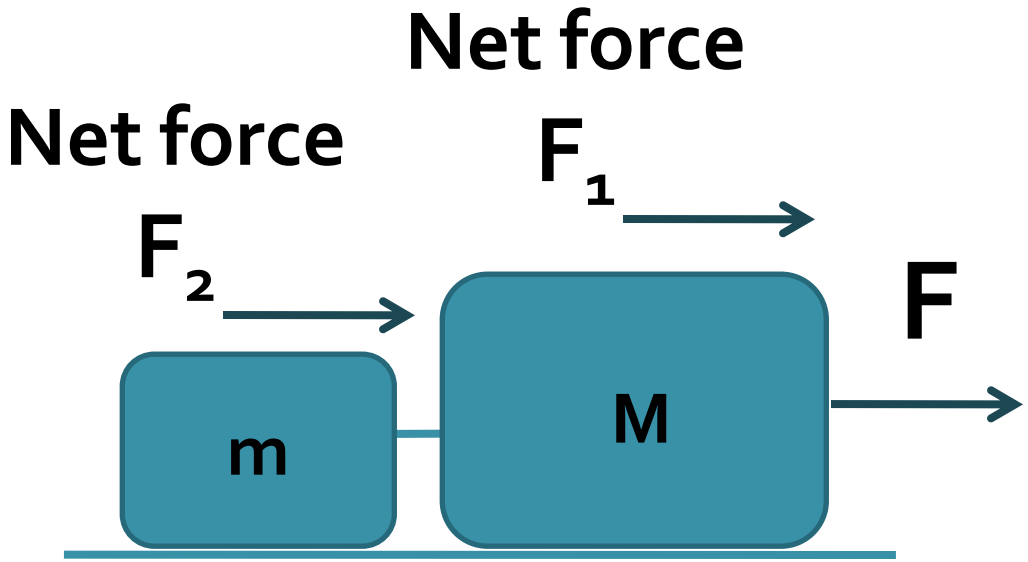
A. Yes

B. No

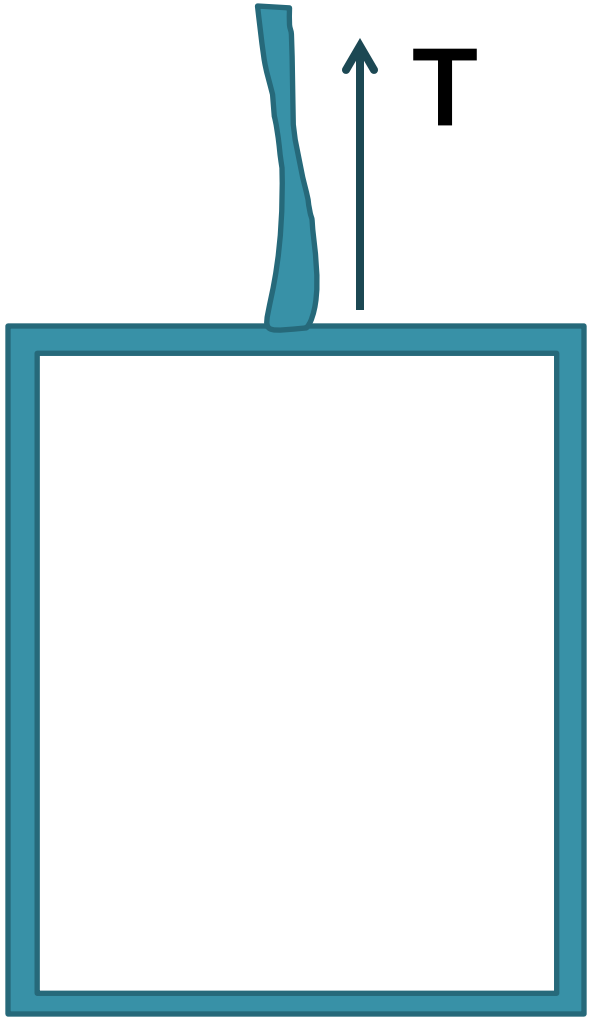


- **Clicker Q: On a frictionless surface, you are pulling two objects that are connected by a string, with a force F and a constant acceleration. Assuming M > m, which of the following is true?**

A. $F_1=F_2=F$
B. $F_1<F_2<F$
C. $F_2<F_1<F$
D. $F<F_1<F_2$
E. $F<F_2<F_1$



- **Clicker Q: An elevator is operated by a rope with tension T. In which of the following cases, is T the greatest?**



A. Going down with a downward acceleration of 3 m/s²
B. Going up with a downward acceleration of 1 m/s²
C. Going down with an upward acceleration of 2 m/s²
D. Gown up with an upward acceleration of 1 m/s²