

Unless otherwise noted, the content of this course material is licensed under a Creative Commons BY 3.0 License.  
<http://creativecommons.org/licenses/by/3.0/>

Copyright © 2009, August E. Evrard.

You assume all responsibility for use and potential liability associated with any use of the material. Material contains copyrighted content, used in accordance with U.S. law. Copyright holders of content included in this material should contact [open.michigan@umich.edu](mailto:open.michigan@umich.edu) with any questions, corrections, or clarifications regarding the use of content. The Regents of the University of Michigan do not license the use of third party content posted to this site unless such a license is specifically granted in connection with particular content. Users of content are responsible for their compliance with applicable law. Mention of specific products in this material solely represents the opinion of the speaker and does not represent an endorsement by the University of Michigan. For more information about how to cite these materials visit <http://open.umich.edu/education/about/terms-of-use>

Any medical information in this material is intended to inform and educate and is not a tool for self-diagnosis or a replacement for medical evaluation, advice, diagnosis or treatment by a healthcare professional. You should speak to your physician or make an appointment to be seen if you have questions or concerns about this information or your medical condition. Viewer discretion is advised: Material may contain medical images that may be disturbing to some viewers.

# Physics 140 – Fall 2007

lecture 6 : 20 Sep

## Ch 4/5 topics:

- Newton's laws of motion
- Newton's third law: action-reaction pairs

## Notices:

- first midterm exam is **Thursday, 4 Oct, 6:00-7:30 pm**
- **need alternate time?** Explain your situation in an email
- practice exam posted to Ctools  
try unworked version first (answers on last page), then  
consult solutions

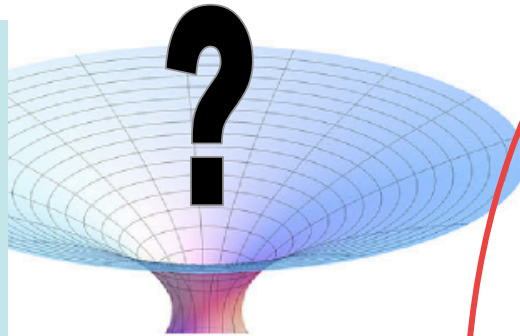
# Fundamental Forces of Nature

Sources: Undetermined

## Gravity

quantum gravity?

binds large objects together (but makes the universe fly apart on large scales!)

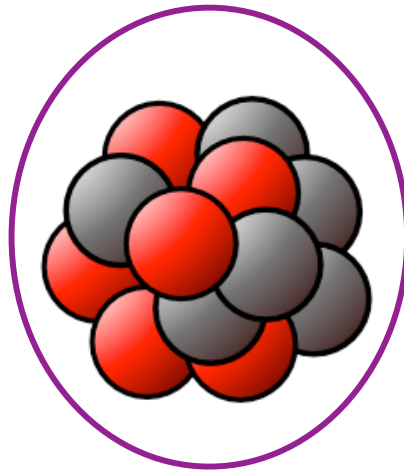


## Electromagnetism



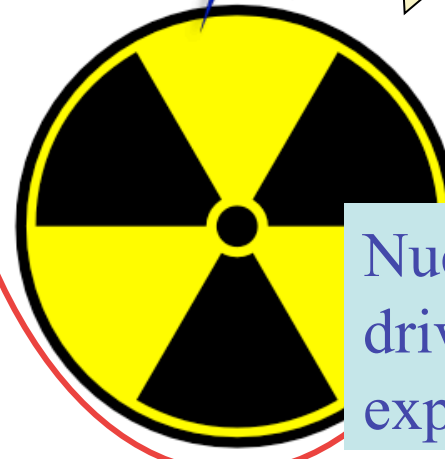
**Life!**  
**Contact forces!**  
**Normal forces!**  
**Friction!**

binds atomic nuclei together, builds elements, powers stars



## Strong Force

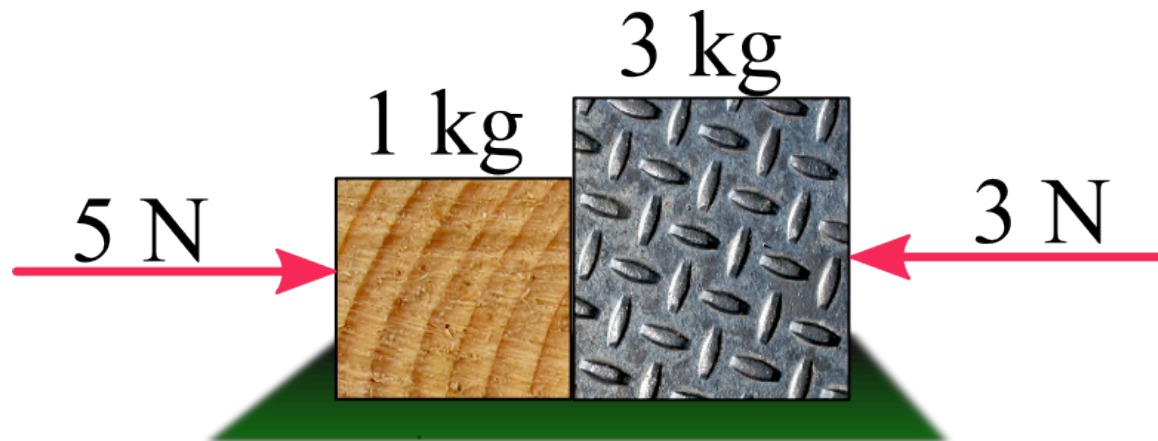
quantum chromodynamics



## Weak Force

quantum electrodynamics

Nuclear fission,  
drives supernova  
explosions



On a horizontal, frictionless surface, the blocks above are being acted upon by two opposing horizontal forces, as shown. What is the magnitude of the **net force** acting on the 3kg block?

- A. zero
- B. 2N
- C. 1.5 N
- D. 1N
- E. More information is needed.

## Newton's Third Law: Action–Reaction Pairs

*“To every action there is always imposed an equal reaction; or, the mutual actions of two bodies upon each other are always equal and directed to contrary parts.”*



Source: Undetermined

Given two bodies (A and B) that affect each other (by direct contact or another means, like gravity), let  $F_{A \text{ on } B}$  be the force on B caused by A and  $F_{B \text{ on } A}$  the force on A caused by B. These forces are equal and opposite

$$F_{B \text{ on } A} = -F_{A \text{ on } B}$$

and are said to form a *third-law pair*. Note that:

- the elements of third-law pairs always act on different objects. Their actions can therefore never cancel.
- third-law pairs can arise with any type of force (gravity, normal force, tension, etc.).
- if one element of a third-law pair is removed, the other must also vanish.

In a tug-of-war, team L pulls on team R with as large a force as it can. Likewise, team R pulls on team L. Eventually, team L prevails, as both teams shift to the left, and team L is declared the winner.



Original Image CC: BY-NC-SA janissary (flickr) <http://creativecommons.org/licenses/by-nc-sa/2.0/deed.en>

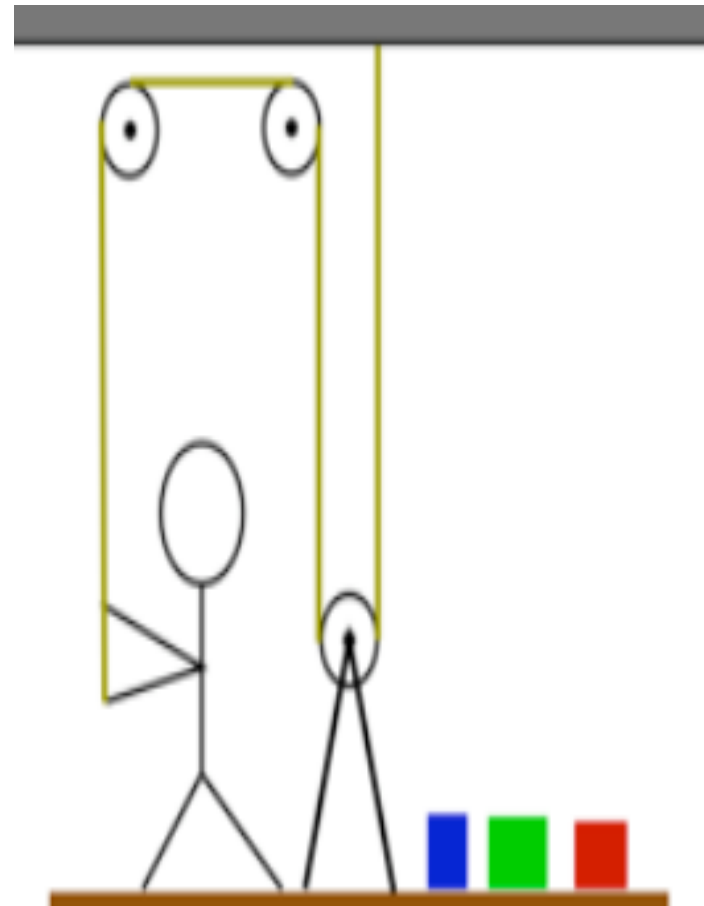
Which statement describing this situation is correct?

1. The winning team exerts a larger force on the losing team than the losing team exerts on the winning team.
2. The losing team exerts a larger force on the winning team than the winning team exerts on the losing team.
- 3. The losing team exerts the same force on the winning team that the winning team exerts on the losing team.

## Some tips for solving Newton's second law problems:

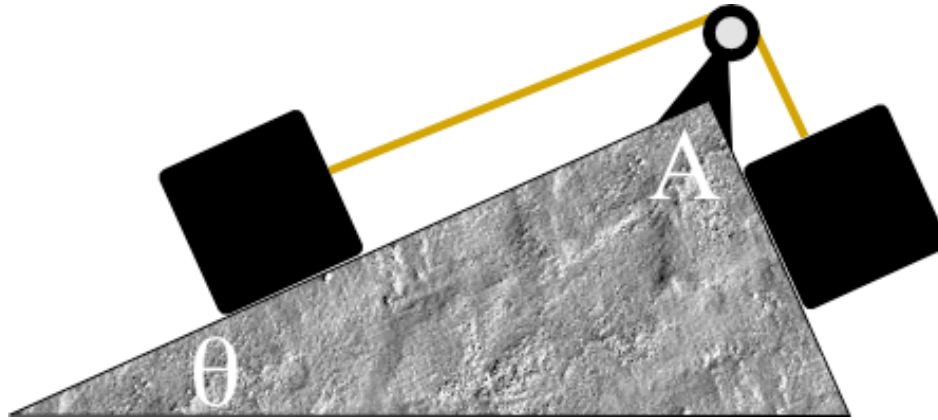
- 1. Think!** Define the system (or set of systems).
  - draw a cartoon and define your coordinate system(s).
  - identify all the forces that are acting
- 2. FBD.** Draw a free-body diagram(s) for the system(s).
  - imagine a bubble enclosing the system
  - “shrink it to a dot”
  - draw vector forces in the chosen coordinate system.
  - apply Newton's 3<sup>rd</sup> law, if needed, at interfaces.
- 3. NSL.** Apply  $\Sigma F = m a$ 
  - in static situations,  $\Sigma F = 0$ .
  - in dynamic situations involving multiple objects, find the links between the objects (e.g., same acceleration)

A hi-rise window installer is pulling a platform and its contents (himself and some equipment) up the side of a building using pulleys and a rope, as shown. If he is pulling so that the tension in the rope is  $T$ , what total force does he exert on the platform and its contents?



- A.  $T$
- B.  $2T$
- C.  $3T$
- D.  $4T$
- E.  $5T$





Two identical masses are attached to either end of a very light rope draped across the very light pulley as shown. If angle A is a right angle, then the magnitude of the acceleration of the blocks expressed in terms of the tilt angle  $\theta$  is

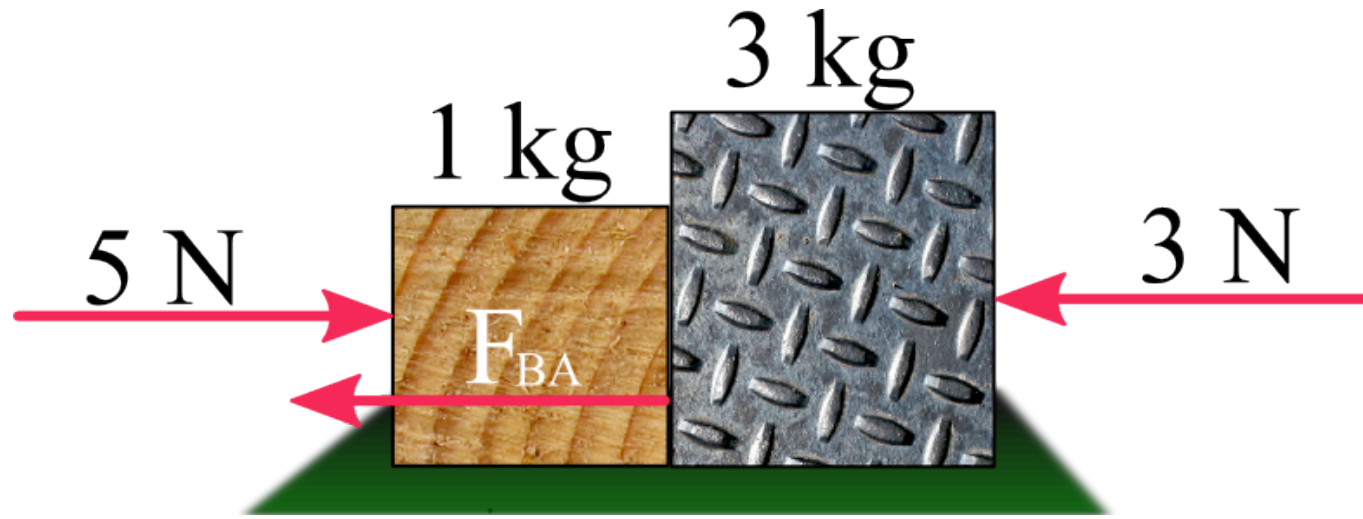
A.  $2g \cos \theta$

B.  $g/2 \sin \theta$

C.  $2g (\cos \theta - \sin \theta)$

D.  $g/2 (\sin \theta + \cos \theta)$

**→** E.  $g/2 (\cos \theta - \sin \theta)$



Taking the +  $i$  direction to the right, what is the contact force that block B exerts on block A?

- A. zero
- B.  $-1.5 i$
- C.  $-4.5 i$
- D.  $1.5 i$
- E.  $4.5 i$
- F.  $-6.0 i$