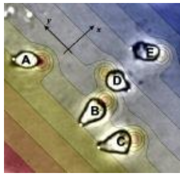
Physics 131-Physics for Biologists I



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Final exam:

Wednesday December 18th 6.30pm-8.30pm

Gravitational Fields

- A *force field* is an idea we use for non-touching forces. It puts a vector at each point in space. The vector direction and length indicate the direction and magnitude of the force **exerted by the surrounding system on our object of interest**.
- For non-touching interactions (e.g. gravity) the force on the object of interest depends on mass. A *gravitational field* is a force field with this "coupling strength" (the mass) divided out so the field does not depend on what test object is used.

$$\vec{g} = \frac{\vec{F}_{\text{acting on } m}}{m}$$

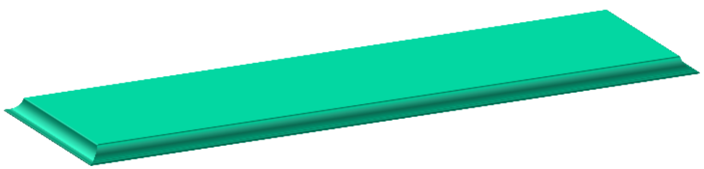
Compare the gravitational field near the surface of the earth for a 1kg object and a 5kg object. Vectors will have

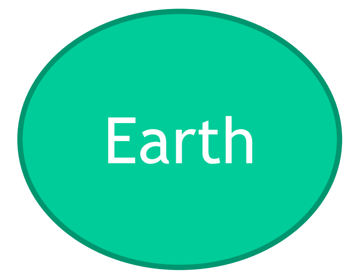
1) The same direction
2) Same magnitude only
3) Same direction and magnitude
4) different direction and magnitude

Gravitational Forces and Fields

- **Sketch the gravitational field (1) near the surface and (2) in another sketch where the earth is small**

(Whiteboard, TA & LA)





- Magnitude and direction of vector depend on position in space! We can ignore that if we are near the surface of the earth.

$$\vec{F}(\vec{r}) = \frac{GM_{Earth}m}{r^2}\hat{r} \qquad \vec{g}(\vec{r}) = \frac{GM_{Earth}}{r^2}\hat{r}$$

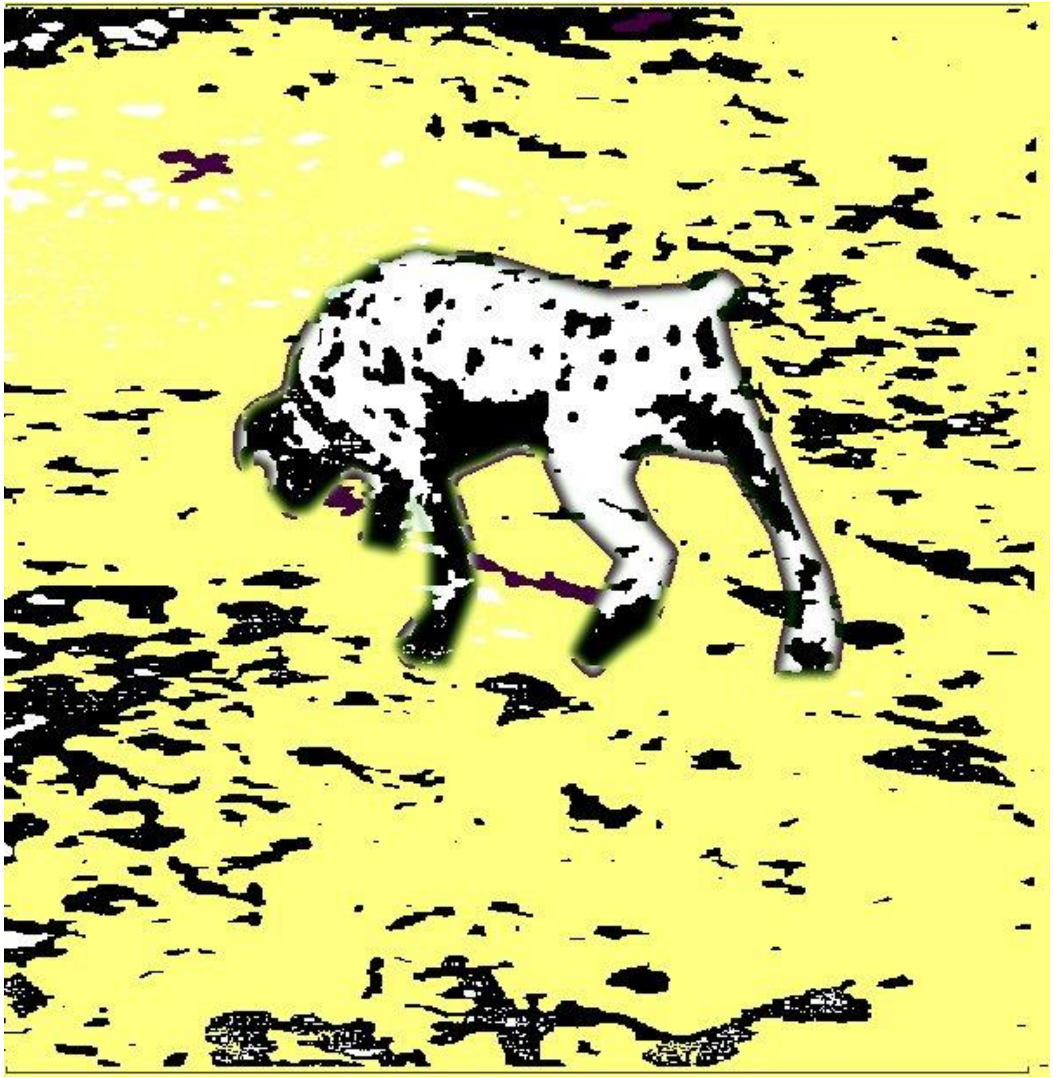
What's this?

- Hint:
  It's an
  animal.
- Hint:
  It's not
  oriented right.

How about this way?

Making sense

- Does this help?



Making sense

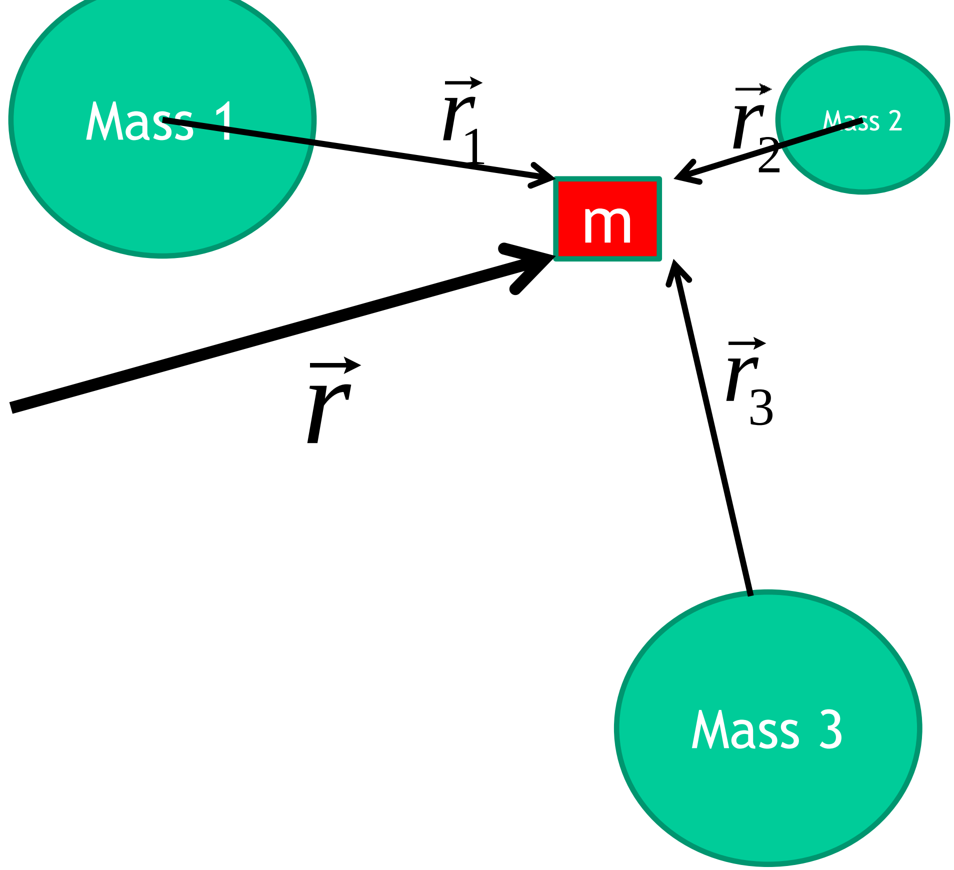
- Our equations don’t just provide a way of calculating something: They express relationships about the physical world.
- We have to “see the dog” in our equations.

Making Sense of the Gravitational Force exerted by Earth on object of mass m

- Changing the object mass m
- Changing Mass of the Earth
- Changing the distance
- Specifying the direction
- Universal prefactor G

$$\vec{F}(\vec{r}) = \frac{G M_{Earth} m}{r^2} \hat{r}$$

Gravitational Forces and fields from multiple interactions ADD



$$\vec{F}_m = \vec{F}_{M_1 \to m} + \vec{F}_{M_2 \to m} + \vec{F}_{M_3 \to m} + \vec{F}_{M_4 \to m} + \ldots$$

$$\vec{F}_{M_1 \to m} = \frac{G M_{M_1} m}{r_1^2} \hat{r}_1$$