PHY131H1F - Class 12

- Today, Chapter 7:
- Newton's Third Law
- Force Interaction Pairs
- · Ropes and Pulleys



Clicker Question 1



Class 12 Preclass Quiz on MasteringPhysics

- This was due this morning at 8:00am
- 828 students submitted the quiz on time.
- 71% of students answered correctly that the mosquito exerts the same amount of force on the truck as the truck exerts on the mosquito.
- 61% of students answered correctly that the propulsion force which accelerates a car is actually static friction!! (18% answered "the car engine")
- 61% of students answered correctly that the "acceleration constraint" in Chapter 7 problems is that two objects have accelerations with the same magnitude.

Class 12 Preclass Quiz on MasteringPhysics

- Some interesting student comments/feedback:
- I don't like mosquitos
- The part about static friction really "propelled" me through the reading. I also found Newton's Third Law to be very "interactive"
- Dynamics is like accounting. ...We are keeping track of forces and balancing the second law of newton like accountants balance their cash statements.
- I like Newton's third law, if action-reaction force is equal, why someone likes to punch the other? dont they get hurt?
- Being able to watch Gravity (with Sandra Bullock and George Clooney) and truly understand the concepts of constant velocity, zero acceleration and what it must be like to drift in outer space makes taking Physics worthwhile!!! P.S. Gravity was Amazing

Last day I asked at the end of class:

Consider the following reasoning, and identify the mistake:

"When you pull a wagon, Newton's 3rd Law states that the wagon pulls back on you with an equal and opposite force. These forces should cancel each other. So it is impossible to accelerate the wagon!"

ANSWER:

- First sentence is correct: the wagon really does pull back on you with an equal opposite force that you pull on the wagon!
- Second and third sentences are not correct: forces cannot cancel each other if they are on different objects.
- The forward static friction on your feet is larger than the backward rolling friction on the wheels of the wagon, so the system of **you and the wagon** has a forward net force, provided by the Earth (static friction). That is why you both accelerate.

Recall from Chapter 6: Drag force in air

 For objects on Earth, with speeds between 1 and 100 m/s and size between 1 cm and 2 m, there is an approximate equation which predicts the magnitude of air resistance:

$$D = \frac{1}{2} C \rho A v^2$$





Example (suggested by student) I throw my roommate out the window (we're on the fourth floor of Elmsley Hall). She has a mass of approximately 55 kg (her opinion), and a radius of 12 inches. The density of air at standard atmospheric pressure and "room temperature" is 1.2 kg/m³. Not very bright, she tries to land feet first (a.k.a., assume the drag coefficient is that of an upright cylinder = .8). What is her terminal velocity? M = 55 kg $Y = 12 kc \left(\frac{2.54 \text{ gm}}{1 \text{ kc}}\right) \left(\frac{1}{10.0 \text{ gm}} = 0.3095 \text{m}}{p = 1.2 \text{ kg}}\right)$

i)
$$(=0.8, A = \pi r^3)$$

free - body diagram:
all).
g ty \vec{D} Terminal velocity: \vec{V} .
mg $\vec{a} = 0$ Constant
 $V = (F_{ret})_y = 0 = D - mg$
 $\vec{D} = mg$
 $\vec{C} p A v^2 = mg$, solve for V :
 $V = \int \frac{2mg}{CpA} = \int \frac{2(55)(qt)}{Cp\pi r^2} = \int \frac{2(55)(qt)}{6.8(12)\pi 63^2}$

3 Newton's Third Law If object 1 acts on object 2 with a force, then object 2 acts on object 1 with an equal force in the opposite direction.



Clicker Question 2

A Mack Truck drives North on the highway, and collides head-on with a mosquito. Which is true?

- A. The Mack Truck does more damage to the mosquito than the mosquito does to the Mack Truck.
- B. The mosquito does more damage to the Mack Truck than the Mack Truck does to the mosquito.
- C. The Mack Truck does the same amount of damage to the mosquito as the mosquito does to the Mack Truck.
- D. Impossible to determine without knowing the speeds of the truck and mosquito.
- E. Don't know or none of the above

FIGURE 7.1 The hammer and nail are interacting with each other.



F = maor a = F / m

- If the force is equal on the truck and the mosquito, is the acceleration equal?
- Acceleration is *higher* if m is *lower* (*F* divided by *m*)
- Mosquito accelerates more, so it receives more damage.

Forces always come in pairs

- Every force interaction involves two objects, and two forces.
- · These forces
 - are equal in strength and opposite in direction.
 - are always the same kind of force (ie gravity, normal,
 - friction, tension, etc.)



FIGURE 7.3 The ocean tides are an indication of the long-range gravitational interaction of the earth and the moon.



- The entire Earth accelerates toward the Moon, due to this pulling force.
- To find the total acceleration, you use the force as calculated for the centre-to-centre distance.
- Since $F_G = GMm/r^2$, the force on the ocean nearer to the moon will be greater, so it will accelerate more than the rest of the Earth, bulging out.

FIGURE 7.3 The ocean tides are an indication of the long-range gravitational interaction of the earth and the moon.



- Similarly, since $F_G = GMn u'r^2$, the force on the ocean further from the moon will be less, so it will accelerate **less** than the rest of the Earth, remaining behind, forming a bulge.
- In general, tidal effects tend to **stretch** objects both toward and away from the object causing the tides.

Clicker Question 3

- A cyclist is pushing on his pedals, and therefore accelerating to the left.
- What is the direction of the force of static friction of the ground on the **back wheel?**
- A. Left
- B. Right
- C. Up
- D. Down
- E. zero



Clicker Question 4

- A cyclist is pushing on his pedals, and therefore accelerating to the left.
- What is the direction of the force of static friction of the ground on the <u>front wheel</u>?
- A. Left
- B. Right
- C. Up D. Down
- E. zero



Announcement



- Starting tomorrow in Practicals you will be in NEW TEAMS! Your TAs will assign you to a new pod and you will work with your new team for the rest of the semester.
- Forming effective teams with strangers is a life skill.



Survey Question

- · Have you ever used a tape-measure?
- A. Yes
- B. No
- C. I would rather not answer that



Car/Earth Friction Interaction



- · Consider an accelerating car.
- · The tires of the car are pushing backward on the Earth (static friction).
- The Earth is pushing forward on the tires of the car (static friction).

Rocket/Gas Pressure Interaction



- · Consider a rocket accelerating upward.
- The rocket is pushing down on the expelled gas (pressure).
- · The expelled gas is pushing up on the rocket (pressure).

Clicker Question 5

Man/Rope Tension Interaction

- · This man is pulling the rope to the left.
- What is the other force in this interaction?

 $\vec{F}_{1,2} = \vec{F}_{2,n}$ A. His feet are pushing the ground to the right.

- B. The ground is pushing his feet to the left.
- C. The rope is pulling the man to the right.
- D. Gravity of the Earth is pulling the man down.
- E. Gravity of the man is pulling the Earth up.

Clicker Question 6



Basketball/Earth Gravity Interaction

- Consider a basketball in freefall.
- · Gravity is pulling this ball down.
- · What is the other force in this interaction?
- The thrower's feet are pushing the ground А down.
- В. The ground is pushing the thrower's feet up.
- C. Gravity of Earth is pulling the thrower down.
- D. Gravity of the ball is pulling the Earth up.
- E. Air is pushing the ball up.

Basketball/Earth Gravity Interaction



- · The Earth is pulling down on the ball.
- · The ball is pulling up on the Earth.

The Massless String Approximation

FIGURE 7.22 The string's tension pulls forward on block A, backward on block B. (b) $\vec{T}_{S \text{ on } A} = \vec{T}_{A \text{ or } A}$ (a) $\vec{T}_{\text{B on S}} = \vec{T}_{\text{S on B}}$ в A

Often in physics problems the mass of the string or rope is much less than the masses of the objects that it connects. In such cases, we can adopt the following massless string approximation: Tension along a string is Constant.

 $T_{\rm B \ on \ S} = T_{\rm A \ on \ S}$ (massless string approximation)



Acceleration constraints

Objects that are constrained to move together must have accelerations of equal magnitude: $a_{\rm A} = a_{\rm B}$. This must be expressed in terms of components, such as $a_{Ax} = -a_{By}$.



Example

2

=)

A cart of mass M is on a track which is at an angle of θ above the horizontal. The cart is attached to a string which goes over a pulley; the other end of the string is attached to a hanging mass, m. What is the acceleration of the cart?

objects





Define

f.b.d. of m;



Before Class 13 on Wednesday ... my last class!

- Please read the first 3 sections of Knight Chapter 8
- If you haven't done Problem Set 5 yet it's due tonight by 11:59pm!
- Something to think about: A ball is whirled on a string in a vertical circle. As it is going around, the tension in the string is

A.constant.

- B.greatest at the top of the motion
- C.greatest at the bottom of the motion
- D.greatest somewhere in between the top and bottom.