Week 5 Tutorial

Tutorial Section T01

14h-15h Friday

Tutorial TA: James C. Dufresne

Tutorial Structure

- Introduction
- Question 1
- Problem Solving Framework
- Question 2
- Problem Solving Framework
- Q&A

Question 1

3. When a cow swats a mosquito with its tail in mid-air,

(a) compare the size of the forces that the tail and the mosquito feel from each other. /2

(b) compare the size of accelerations that the collision between the cow's tail and the mosquito produces for both the tail and the mosquito. /2

1. Framing

Visual Representation

Assumptions and Simplifications

Relevant Concepts

Information Needed

Similar Problems

2. Planning

Solution Plan

Rough Estimate

3. Execution

Carry-out Plan for solving
- Work in algebra/symbols until the BITTER end
- Plug in numbers at the LAST step

4. Answer Checking

Compare to Estimate

Units Check

Limits Test

Getting (UnStuck)

Reference: Template for teaching and assessment of problem solving in introductory physics

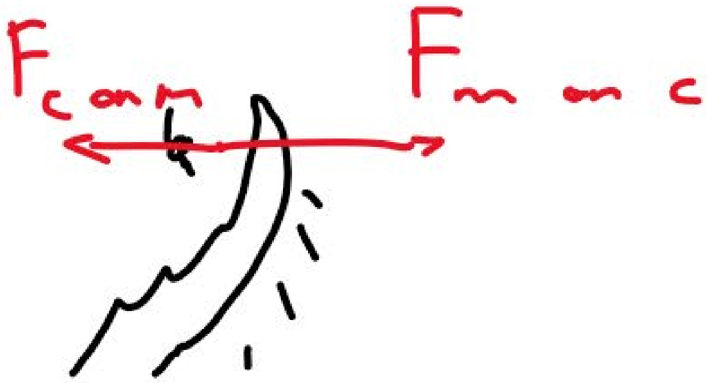
1. Framing

- Visual representation: Draw free body diagrams to show the forces being applied on the cow and the mosquito.
- Assumptions and simplifications: Only consider 1-D.
- Relevant concept: Newton's third law.
- Information needed: Forces being applied on the cow and the mosquito by each other. How do their masses compare?
- Similar problems: Any problem that involves drawing free body diagrams.

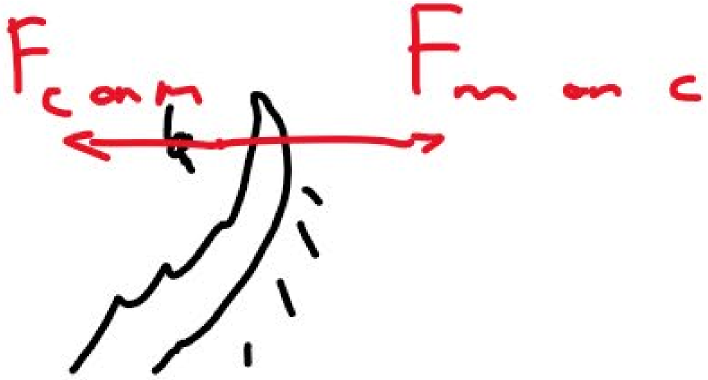
2. Planning

- Rough estimate: Visualize the free body diagram. How do the mass of the mosquito and the cow’s tail compare? F=ma
- Solution plan: Determine how the two objects exert force on each other. Determine how different masses affect the acceleration.

3a



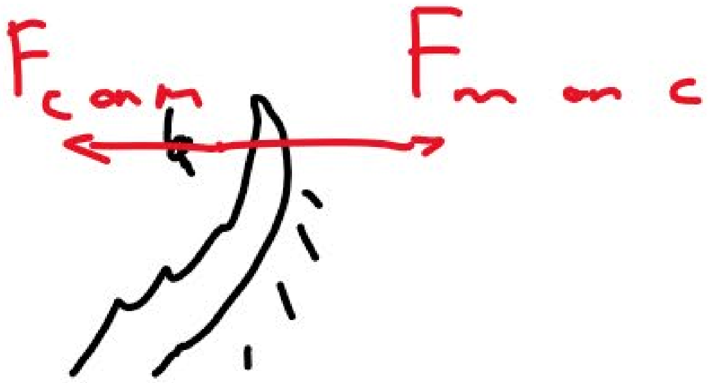
3a



Newton's third law: Each force has an equal and opposite reaction force

$$F_{AB} = -F_{BA}$$

3a



Newton's third law: Each force has an equal and opposite reaction force

$$F_{AB} = -F_{BA}$$

$\therefore$

ANS The size of the forces felt by the mosquito and the cow are equal in magnitude. This is due to Newton's third law.

Solution

3. When a cow swats a mosquito with its tail in mid-air,

(a) compare the size of the forces that the tail and the mosquito feel from each other.

$F_{tm} = F_{mt}$ (1pt) /2

Newton's third law. (1pt)

(b) compare the size of accelerations that the collision between the cow's tail and the mosquito produces for both the tail and the mosquito.

3b

$F = ma$

3b

$$F = ma$$

$$F_{cm} = -F_{mc}$$

3b

$$F = ma$$

$$F_{cm} = -F_{mc}$$

$$|F_{cm}| = |F_{mc}|$$

3b

$$F = ma$$

$$F_{cm} = -F_{mc}$$

$$|F_{cm}| = |F_{mc}|$$

$$m_m a_m = m_c a_c$$

3b

$$F = ma$$

$$F_{cm} = -F_{mc}$$

$$|F_{cm}| = |F_{mc}|$$

$$m_m a_m = m_c a_c$$

$$\frac{\text{small}}{\text{large}} \quad \frac{m_m}{m_c} = \frac{a_c}{a_m}$$

$$\frac{m_m}{m_c} \rightarrow \ll 1$$

3b

$$F = ma$$

$$F_{cm} = -F_{mc}$$

$$|F_{cm}| = |F_{mc}|$$

$$m_m a_m = m_c a_c$$

$$\frac{\text{small}}{\text{large}} \quad \frac{m_m}{m_c} = \frac{a_c}{a_m}$$

$$\frac{m_m}{m_c} \to \ll 1$$

$\therefore$ The mosquito accelerates much more than the cow.

Solution

3. When a cow swats a mosquito with its tail in mid-air,

(a) compare the size of the forces that the tail and the mosquito feel from each other.

$F_{tm} = F_{mt}$ (1pt) /2

Newton's third law. (1pt.)

(b) compare the size of accelerations that the collision between the cow's tail and the mosquito produces for both the tail and the mosquito. /2

$m_m << m_t$ so $m_t a_t = m_m a_m$

The mosquito accelerates much more. (1pt.) $\frac{a_m}{a_t} = \frac{m_t}{m_m} >> 1$ (1pt.)

4. Answer Checking

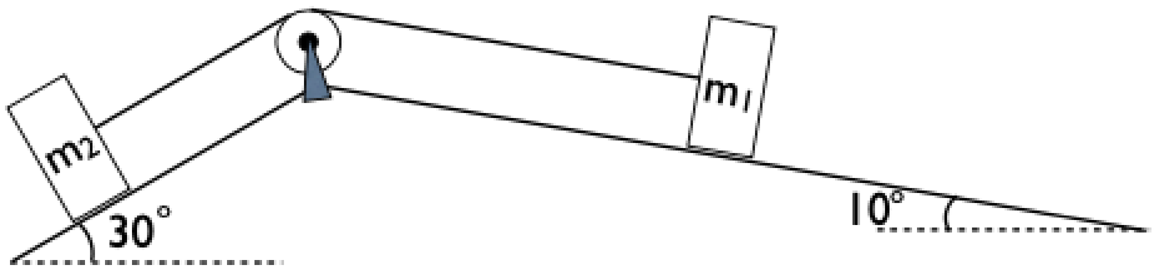
Compare to estimates: Does this make sense based on your FBD?

Units: Not applicable

Limits: Not applicable

Getting (UnStuck)? ...

Question 2



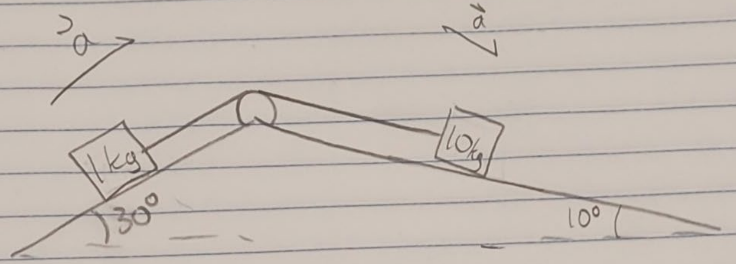
1. (a) Two masses $m_1 = 10$ kg and $m_2 = 1$ kg are connected by a light rope which passes over a light, low friction pulley between low friction slopes of 30° and 10° as shown in the figure. Approximating the masses of the rope and pulley to be negligible and the friction of both the slopes and the pulley to be negligible, find the acceleration (/2) of mass m_2 up the slope. (Draw free body diagrams (/10), axes and acceleration vectors, and write Newton's second law equations in components independently (/10) for both masses.) /22

1. Framing

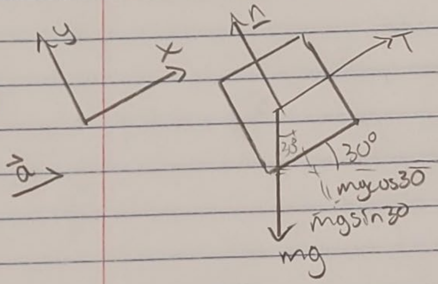
- Visual representation: Look at the diagram and draw relevant FBD's.
- Assumptions and simplifications: Frictionless surface. Acceleration of m1 and m2 are due to each other.
- Relevant concept: Newton's laws of motion.
- Information needed: Acceleration of mass 1 and mass 2, FBD's, Newton's second law equations.
- Similar problems: 1-D block on a slope, etc.

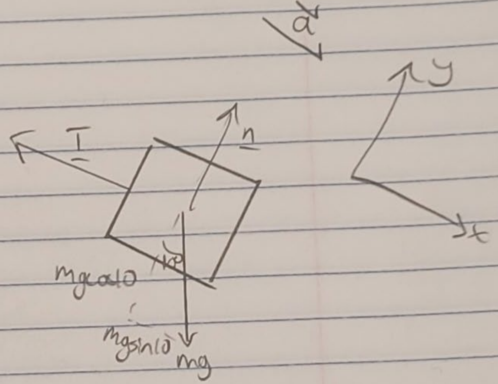
2. Planning

- Rough estimate: How do you expect the system to react?
- Solution plan: Draw FBD's for each mass. Substitute equations into FBD to determine acceleration of the system.



a_{m_2} up the slope = ?





$\Sigma F_x = ma$

$T - m_2 g\sin 30 = ma$

$\Sigma F_y = 0$

$n - mg\cos 30 = 0$

$\Sigma F_x = ma$

$mg\sin 10 - T = ma$

$\Sigma F_y = 0$

$n - mg\cos 10 = 0$

$T - m_2 g\sin 30 = m_1 g\sin 10 - T$

$ma = m_1 g\sin 10 \cancel{- T + T} - mg\sin 30$

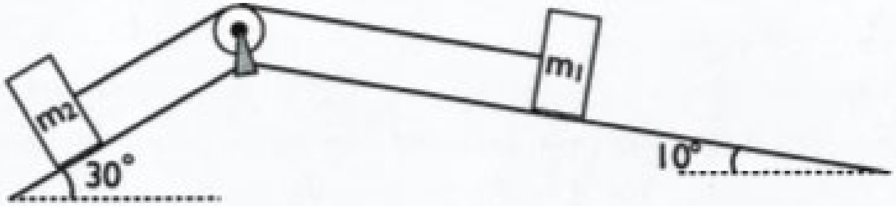
$(m_1 + m_2)a = m_1 g\sin 10 - m_2 g\sin 30$

$11a = (98\sin 10) - (9.8\sin 30)$

$11a = 12.12$

$a = 1.1\ m/s^2$

Solution



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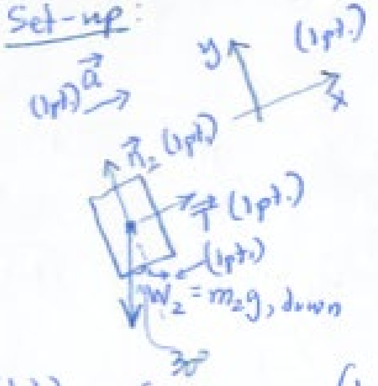
Set-up:

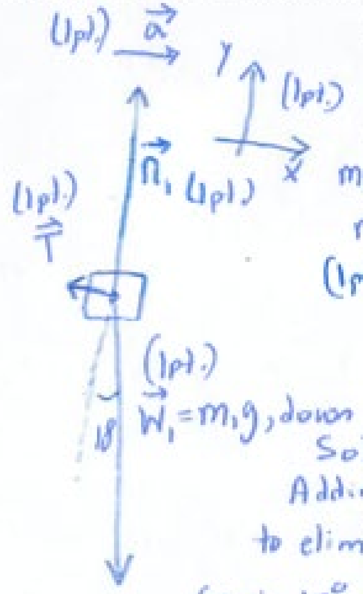


$$T - m_2 g \sin 30^\circ = m_2 a \quad (1)$$

(1pt.) (1pt.) (1pt.) (or W_2)

$$n_2 - m_2 g \cos 30^\circ = 0$$

(1pt.) (1pt.)



(1pt.) (1pt.) (1pt.)

$$m_1 g \sin 10^\circ - T = m_1 a \quad (2)$$

$$n_1 - m_1 g \cos(10^\circ) = 0$$

(1pt.) (1pt.)

Solve:
Adding equations (1) and (2) to eliminate T: (1pt.)

$$(m_1 \sin 10^\circ - m_2 \sin 30^\circ) g = (m_1 + m_2) a$$

$$a = g\left(\frac{m_1 \sin 10^\circ - m_2 \sin 30^\circ}{m_1 + m_2}\right)$$

$$= g\left(\frac{10\,\text{kg} \sin 10^\circ - 1\,\text{kg} \sin 30^\circ}{11\,\text{kg}}\right) = 0.11 g$$

$g = 9.8\ m/s^2$

$$= 1.1\ m/s^2. \text{ (1pt.)}$$

4. Answer Checking

Compare to estimates: Is this what you expected?

Units: Check your units. Do they make sense?

Limits: Not applicable.

Getting (UnStuck)? …