Week 12 Tutorial

Tutorial Section

Tutorial Time

Tutorial TA Name

Tutorial Structure

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

Question 1

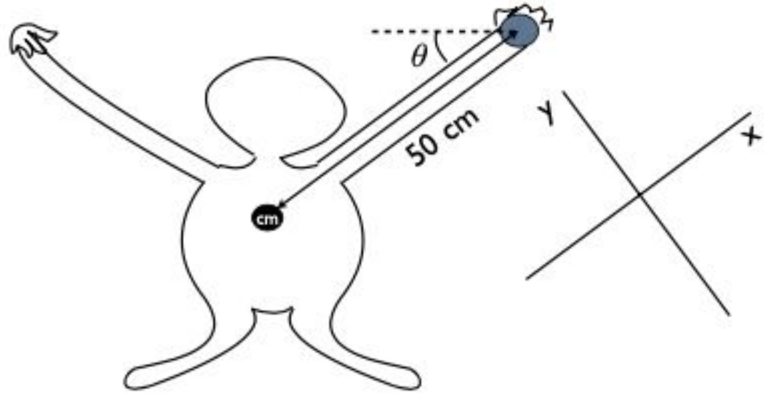

FIG. 1:

1. In brachiation, monkeys move from tree branch to tree branch by swinging from their arms.

(a) In the position shown in Fig. 1 (left), draw a free body diagram on the provided axes (Fig. 1 (right)) for the monkey, assuming that it is momentarily at rest. (Label the forces $\vec{F}$ and $\vec{w}$ with subscripts on each, and include the angle). /5

Let the monkey's mass be 10 kg, $\theta = 30°$, and the centre of mass of the monkey to be 50 cm from its centre of mass as shown in Fig. 1.

(b) Calculate the torque exerted by $\vec{F}_{\text{m on b}}$ about the branch. /3

(c) Calculate the torque exerted by the monkey's mass about the branch. /5

(d) The moment of inertia of a solid sphere about its centre is $\frac{2}{5}MR^2$. If the monkey's mass can be treated as a sphere of radius 30 cm find the moment of inertia of the monkey about its centre. /2

Question 1

(e) The parallel axis theorem states that the moment of inertia of an object of mass m about an axis a distance d from its centre of mass is given by $I = I_{cm} + md^2$. Find the moment of inertia of the spherical monkey about the branch. /2

(f) Find the angular acceleration of the monkey. /3

(g) Find the tangential acceleration of the monkey's centre of mass about the branch. /2

Problem Solving Framework

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **16**, 010123 (2020)

Template for teaching and assessment of problem solving in introductory physics

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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

2. Planning

3. Execution

4. Answer Checking

1. Framing

- Visual representation: Look at the figure provided to see what's going on in this problem.
- Assumptions and simplifications: Only consider this question in 2D.
- Relevant concept: Angular motion and torque
- Information needed: Refer to individual questions.
- Similar problems: Most questions involving angular motion and torque

2. Planning

- Rough estimate: Think what you'd expect your solution to be for each individual problem.
- Solution plan: See slides 12-15

3. Execution

- See solution on slide 12-15. Carry out the calculation, plug in the numbers at the last step when necessary.

4. Answer Checking

Compare to estimates: Does your answer make sense for that part of the problem?

Units: Think about what units we use for momentum and impulse in this problem.

Limits: ...

Getting (UnStuck): ...

Solution

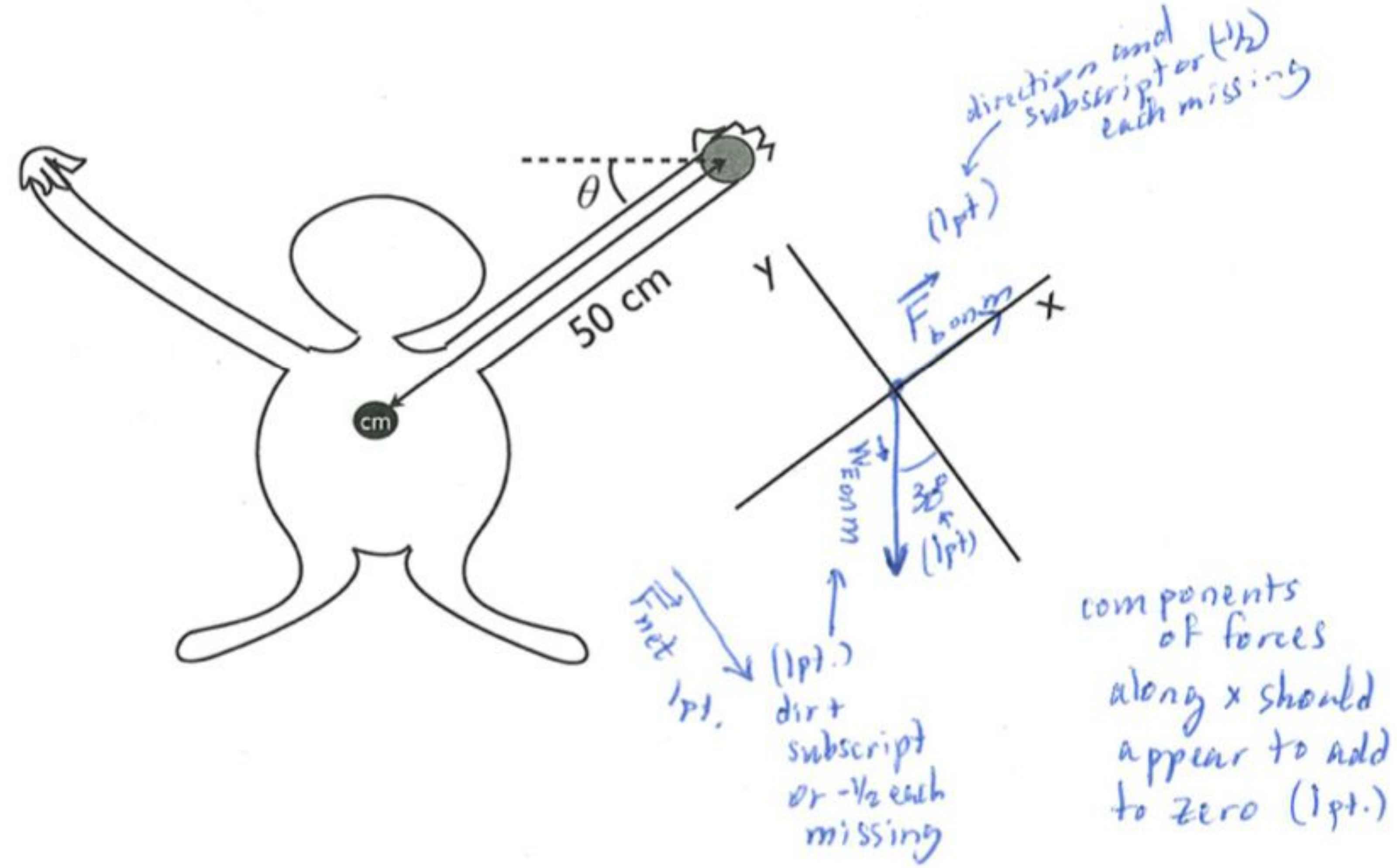


FIG. 1:

1. In brachiation, monkeys move from tree branch to tree branch by swinging from their arms.

(a) In the position shown in Fig. 1 (left), draw a free body diagram on the provided axes (Fig. 1 (right)) for the monkey, assuming that it is momentarily at rest. (Label the forces $\overrightarrow{F}$ and $\overrightarrow{w}$ with subscripts on each, and include the angle). /5

Solution

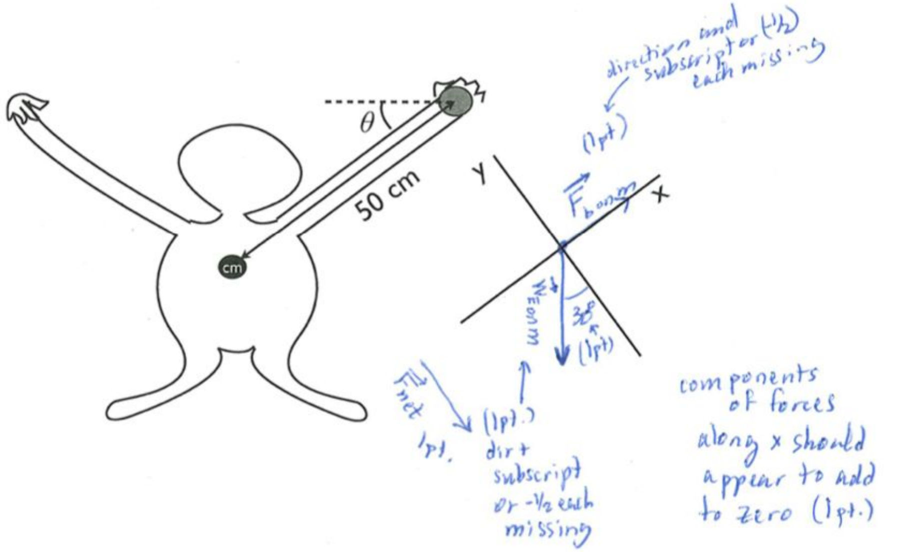


FIG. 1:

1. In brachiation, monkeys move from tree branch to tree branch by swinging from their arms.

Let the monkey's mass be 10 kg, $\theta = 30°$, and the centre of mass of the monkey to be 50 cm from its centre of mass as shown in Fig. 1.

(b) Calculate the torque exerted by $\vec{F}_{mon\,b}$ about the branch. /3

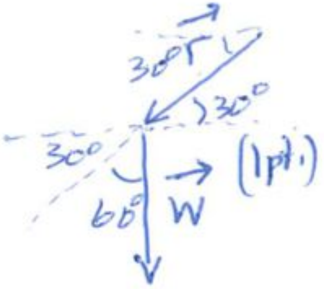
$\tau = r_\perp F$

$= rF\sin\phi$ (1pt)

$r = 0$ since force applied at point of pivot. (1pt.)

$\tau = 0\ N\cdot m$ (1pt.)

(c) Calculate the torque exerted by the monkey's mass about the branch. /5



The angle between $\vec{r}$ and $\vec{w}$ is $\phi = 60°$ (1pt.)

so $\tau = rF\sin\phi = (0.50m)(9.8m/s^2)(10kg)\sin(60°)$ (1pt.)

$= 42.4 N\cdot m$ (1pt.)

which is positive since it tends to cause a counterclockwise rotation. (1pt.)

Solution

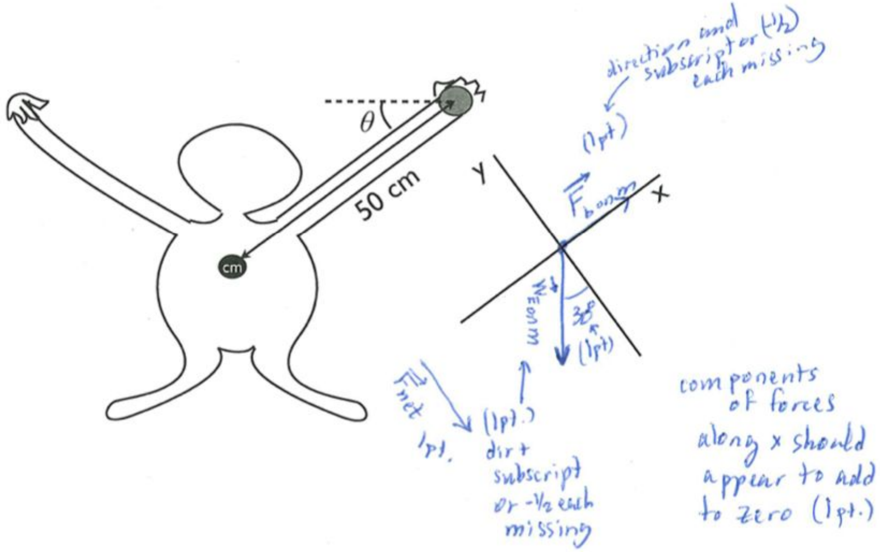


FIG. 1:

1. In brachiation, monkeys move from tree branch to tree branch by swinging from their arms.

(d) The moment of inertia of a solid sphere about its centre is $\frac{2}{5}MR^2$. If the monkey's mass can be treated as a sphere of radius 30 cm find the moment of inertia of the monkey about its centre. /2

$$I_{cm} = \frac{2}{5}MR^2 = \frac{2}{5}(10\,kg)(0.3\,m)^2 = 0.36\ kg\cdot m^2$$

(1pt.) (1pt.)

(e) The parallel axis theorem states that the moment of inertia of an object of mass m about an axis a distance d from its centre of mass is given by $I = I_{cm} + md^2$. Find the moment of inertia of the spherical monkey about the branch. /2

$$I_{cm} = 0.36\,kg\cdot m^2$$

$$I = I_{cm} + md^2$$

$$= 0.36\,kg\cdot m^2 + (10\,kg)(0.5\,m)^2 = 2.86\ kg\cdot m^2$$

(1pt.) (1pt.)

Solution

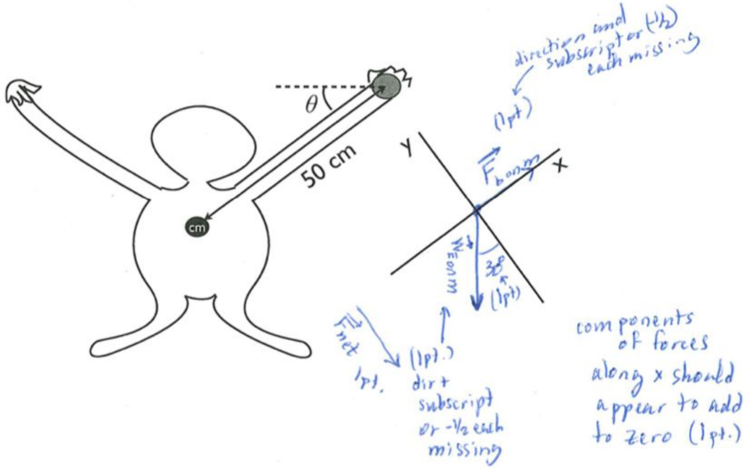


FIG. 1:

1. In brachiation, monkeys move from tree branch to tree branch by swinging from their arms.

(f) Find the angular acceleration of the monkey. /3

$$\alpha = \frac{\tau}{I} = \frac{42.4\,N\cdot m}{2.86\,kg\cdot m^2} = 14.8\,rad/s^2$$

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

(g) Find the tangential acceleration of the monkey's centre of mass about the branch. /2

$$a_t = r\alpha = (0.5\,m)(14.8\,rad/s^2)$$

(1pt.)

$$= 7.4\,m/s^2$$

(1pt.)

(h) Your result from part (g) is not the same as you would get from solving for the acceleration from the free body diagram in part (a). Explain why this is, referring to the particle model. /2

The particle model would treat $I = mr^2$, so since the monkey's mass is more distributed, the result will be different from just solving for a_y from part (a), which would have given 8.49 m/s².