Physics 7A-1 MT1 Lecture 1

Kaleo Leonhardt

TOTAL POINTS

94 / 100

QUESTION 1

Problem 1 20 pts

1.1 1a 4 / 4

✓ + **4 pts** correct answer

+ **1 pts** v_c = wR
+ **1 pts** correct y value
+ **1 pts** x = wrt
+ **1 pts** y doesn't move
+ **1 pts** vector decomposition
+ **3 pts** accel. but everything else correct
+ **0 pts** Click here to replace this description.

1.2 1b 4 / 4

✓ + **4 pts** Correct

+ **0 pts** Incorrect
+ **2 pts** correct answer with wrong angle (i.e. no i.c.)
+ **1 pts** angular part without ic
+ **3 pts** angular with ic without R
+ **3.5 pts** off-by 2pi
+ **2 pts** correct ic
+ **1 pts** correc

1.3 1c 4 / 4

✓ + **4 pts** Correct

+ **0 pts** wrong
+ **3 pts** vector addition
- **1 pts** wrong dimensions
+ **1 pts** Click here to replace this description.
- **1 pts** no angular component in terms of omega

1.4 1d 4 / 4

✓ + **4 pts** Correct

+ **0 pts** wrong
+ **3 pts** differentiate reasonable answer
- **1 pts** units
+ **0.5 pts** show that you are differentiating
- **1 pts** theta is undefined
- **1 pts** incorrect differentiation

1.5 1e 4 / 4

✓ + **4 pts** Correct

+ **0 pts** wrong
+ **2 pts** differentiate
+ **2 pts** substitute correct value of r_A
+ **0.5 pts** show that you are differentiating
+ **2 pts** only write derivate dependence
- **1.5 pts** units

QUESTION 2

Problem 2 25 pts

2.1 2a 10 / 10

✓ - **0 pts** Correct

- **1 pts** Sign error (arithmetic)
- **2 pts** Sign error (problem setup)
- **6 pts** Incorrect setup and solution/answer not in terms of given quantities
- **1 pts** Algebra/Simplification error
- **2 pts** T used incorrectly or not at all
- **2 pts** h used incorrectly or not at all
- **2 pts** Incorrect final/initial velocity
+ **1 pts** Some use of relevant kinematics equations
- **0.5 pts** Algebra/Simplification error
- **2 pts** Error in the kinematics equation used
- **3 pts** Correct approach, no/wrong solution, solution in terms of quantities not given in the problem

2.2 2b 15 / 15

✓ - **0 pts** Correct

- **5 pts** Solved for t+T, the time from when the ball passes the bottom of the window to when it reaches its maximum height.

- **- 5 pts** Incorrect use of T and/or incorrect understanding of the time the problem asks for
- **- 5 pts** Answer in terms of lengths/times/angles not given in the problem
- **+ 3 pts** Some relevant kinematics equations used
- **- 10 pts** Incorrect or incomplete method and result
- **+ 4 pts** Some relevant kinematics equations used
- **+ 5 pts** Some relevant kinematics equations used
- **- 1 pts** Answer in terms of quantities not given in the problem
- **- 3 pts** Did not use v_y=0 at the maximum height.
- **- 1 pts** Algebra/Simplification error
- **- 0 pts** Correct (using incorrect part a)
- **- 2 pts** Sign error: negative time
- **- 2 pts** Use of quantities not given in the problem
- **- 2 pts** Algebra/simplification error
- **- 1 pts** Assumed constant velocity for part of the motion
- **- 1 pts** Algebra/Simplification error
- **- 1 pts** Sign error on acceleration

QUESTION 3

Problem 3 25 pts

3.1 3a **5 / 5**

- ✓ **+ 5 pts Correct**
- **+ 3 pts** Drew a force diagram on the pulley
- **+ 0 pts** None of the above
- **+ 2 pts** Drew a force diagram on the pulley, but didn't use the force diagram, or the force diagram was way off, or incorrectly used a force diagram they didn't draw

3.2 3b **6 / 6**

- ✓ **- 0 pts Correct**
- **- 2 pts** Inaccurate equations
- **- 2 pts** inaccurate force diagrams
- **- 4 pts** No force diagram
- **- 1 pts** Sign inconsistency

3.3 3c **2 / 7**

- **- 0 pts** Correct
- ✓ **- 2 pts Sign inconsistency**
- ✓ **- 3 pts Had the right ideas, but put the 2 in the wrong spot**
- **- 5 pts** Incorrect magnitude
- **- 7 pts** all wrong
- **- 0 pts** Click here to replace this description.

3.4 3d **6 / 7**

- **- 0 pts** Correct or good math using above eqs
- **- 7 pts** Empty, or no progress made, or uses equations that don't stem from previous parts of the problem and are wrong, or has a or g in final answer
- ✓ **- 1 pts sign error**
- **- 2 pts** substitution error
- **- 2 pts** multiplication/addition error
- **- 1 pts** missed the final step, i.e. didn't write down the answer
- **- 2 pts** another mult/add error

QUESTION 4

Problem 4 30 pts

4.1 4a **10 / 10**

- ✓ **+ 10 pts Correct**
- **+ 1 pts** Drew a FBD for the glass
- **+ 2 pts** Drew a correct FBD or used correct forces in F = ma for glass specifically
- **+ 3 pts** Correctly found frictional force on glass
- **+ 1 pts** Attempted F = ma on the glass
- **+ 1 pts** Found acceleration of glass
- **+ 1 pts** Found position of glass from constant acceleration
- **+ 2 pts** Found positions of glass and cloth from their constant accelerations
- **+ 1 pts** Identified geometric condition of water spilling involving both glass and cloth position: (xC - xG = W/2)
- **+ 2 pts** Correctly solved for time when positions satisfy spillage condition
- **+ 1 pts** Solved the wrong problem of when the cloth

has moved a certain distance, not when the glass has slipped a certain distance relative to the cloth, but used force balance and kinematics correctly to do that

- **- 1 pts** Assumed that the glass' acceleration is just a0
- **- 1 pts** Algebra mistakes or misapplication of formulae
- **- 2 pts** Mistakes in analyzing forces on cloth
- **- 3 pts** Serious conceptual errors when analyzing cloth or system as a whole
- **- 3 pts** Forgot to consider relative motion of cloth and glass, considering just one instead
- **+ 10 pts** Correct with a few errors
- **- 2 pts** Unclear work or conceptual errors
- **+ 0 pts** Blank

4.2 4b 5 / 5

- ✓ **+ 5 pts Correct, at least given previous answers**
- **- 1 pts** Algebra errors or minor misapplication of formulae
- **+ 2 pts** Wrote and used constant-acceleration kinematic equation v = at
- **+ 1 pts** Plugged in tS from 4(a)
- **+ 1 pts** Plugged in a from 4(a)
- **- 1 pts** Incorrect formula for acceleration of glass
- **+ 5 pts** Reasonable, at least given previous answers, but with some conceptual errors
- **- 2 pts** Mistaken assumption about how far the glass has moved in total as opposed to relative to the cloth
- **- 3 pts** Mistaken assumption that the glass is moving with constant speed
- **- 1 pts** Plugged in wrong values for a_glass or tS
- **- 2 pts** Used kinematic formula incorrectly
- **- 1 pts** Introduced variable that wasn't given
- **+ 0 pts** Misunderstanding of friction keeping objects stationary
- **+ 0 pts** Zero justified work
- **+ 1 pts** Wrote a relevant kinematics equation
- **- 2 pts** Incorrect force analysis

4.3 4c 5 / 5

- ✓ **+ 5 pts Correct, at least given previous work**
- **+ 2 pts** Reasonable work, but with a mistaken assumption about how the glass is moving relative to the table and cloth, making the answer just the W/2 given in the problem or something similar
- **+ 1 pts** Attempted to use a kinematics equation
- **+ 3 pts** Wrote and used relevant kinematics equation correctly
- **+ 1 pts** Plugged in correct a and tS
- **- 1 pts** Answer negative or has wrong units
- **- 2 pts** Mistakes in force analysis of cloth
- **- 2 pts** Mistakes in application of kinematics formula
- **- 1 pts** Used a variable not given in the problem
- **+ 5 pts** Reasonable, but with some errors
- **- 2 pts** Assumed an initial velocity
- **- 3 pts** Assumed constant velocity
- **- 2 pts** Lacking justification
- **- 1 pts** Answer has wrong units
- **+ 1 pts** Some kinematics, but with the wrong answer and no justification to explain the path to it
- **+ 0 pts** Zero correct, relevant work

4.4 4d 10 / 10

- ✓ **- 0 pts Correct**
- **- 2 pts** Missed an extra mu*M*g from the second frictional force
- **- 5 pts** Incorrectly took the cloth and glass to have the same acceleration instead of moving separately
- **- 3 pts** Only considered one frictional force on cloth
- **- 5 pts** Force analysis missing a lot of detail or making major errors or incorrect assumptions
- **- 2 pts** Took acceleration in x to be zero
- **- 2 pts** Error in force analysis of cloth
- **- 2 pts** No force analysis
- **- 2 pts** Used a variable not given in the problem
- **- 5 pts** Used an important variable not given in the problem
- **- 2 pts** Worked with inequalities instead of equations
- **- 1 pts** Sign error
- **- 1 pts** Algebra errors
- **- 5 pts** Took F to be acting on the glass as well as

on the cloth

- **3 pts** Reasoning quite unclear
- **4 pts** Expression for acceleration incorrect; in particular, the cloth just has acceleration a0
- **0.5 pts** Missed a subscript
- **10 pts** Zero or very little correct, relevant, justified work

UNIVERSITY OF CALIFORNIA AT BERKELEY

Physics 7A – Lecture 1 (Stahler)

Fall 2019

FIRST MIDTERM

Please do all your work in this exam, in the blank spaces provided.

You must attempt all four problems. If you become stuck on one, go on to another and return to the first one later. Be sure to show all your reasoning, since partial credit will be allotted. No credit will be given for unjustified answers. **Remember to circle your final answer.**

Please complete the following. On each subsequent page, please write your SID in the upper right corner, where indicated.

Full name: Kaleo Leonhardt

SID: 3033789282

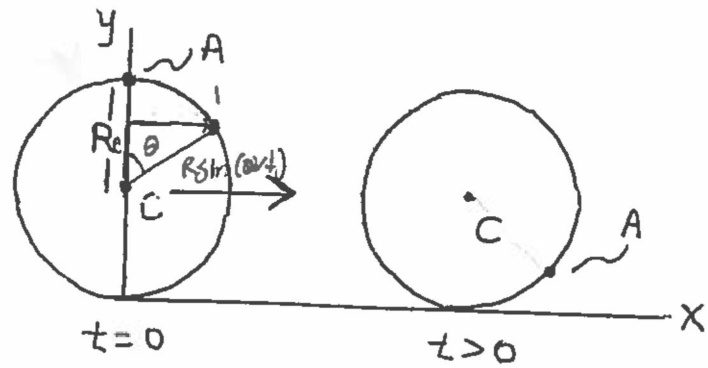
Discussion section and GSI: Mario D'Andrea, TTh 8:00AM to 10:00AM

Signature:

SID: 3088789282

Problem 1 (20 points)

A wheel of radius R rolls to the right horizontally (in the positive x-direction) without slipping. At $t = 0$, the wheel's center is directly above the origin. Consider two points fixed to the wheel. Point A is directly above the center at $t = 0$, but subsequently moves to the right. Point C is always at the wheel's center. Let ω be the angular speed of the wheel about this center.



(a) Find $r_C(t)$, the vector position of point C, measured with respect to the origin, as a function of time. Be sure to show clearly the x- and y-components of this vector.

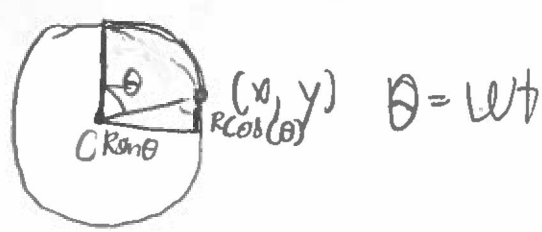
$r_C(t) = \langle 0 + x(t), R + y(t) \rangle$ $x(t) = vt \Rightarrow v = \omega R \Rightarrow x(t) = \omega R t$

$r_C(t) = \langle \omega R t, R \rangle$ No motion in y direction, so $y(t) = 0$ ↖ No slip condition

(b) Find $r'_A(t)$, the vector position of point A *with respect to the moving point C*.

$r'_A(t) = \langle 0 + x(t), 0 + y(t) \rangle$ $x(t) = R\sin\theta$ $y(t) = R\cos\theta$

$r'_A(t) = \langle R\sin\omega t, R\cos\omega t \rangle$ $x(t) = R\sin\omega t$ $y(t) = R\cos\omega t$



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(c) Find $r_A(t)$, the vector position of A, measured with respect to the origin.

$r_A(t) = r_C(t) + r_A'(t)$

$r_A(t) = \langle \omega Rt, R \rangle + \langle R\sin\omega t, R\cos(\omega t) \rangle$

$r_A(t) = R\langle \omega t + \sin\omega t, 1 + \cos\omega t \rangle$

(d) Find $v_A(t)$, the vector velocity of point A with respect to the origin.

$v_A(t) = \frac{d}{dt}\left(R\langle \omega t + \sin\omega t, 1 + \cos\omega t \rangle\right)$

$v_A(t) = R\langle \omega + \omega\cos\omega t, -\omega\sin\omega t \rangle$

$v_A(t) = R\omega\langle 1 + \cos\omega t, -\sin\omega t \rangle$

(e) Find $a_A(t)$, the vector acceleration of point A with respect to the origin. Express your answer in terms of $r_A'(t)$.

$a_A(t) = \frac{d}{dt}\left(R\omega\langle 1 + \cos\omega t, -\sin\omega t \rangle\right)$

$= R\omega^2\langle -\sin\omega t, -\cos\omega t \rangle$

$\boxed{a_A(t) = -\omega^2 r_A'(t)}$

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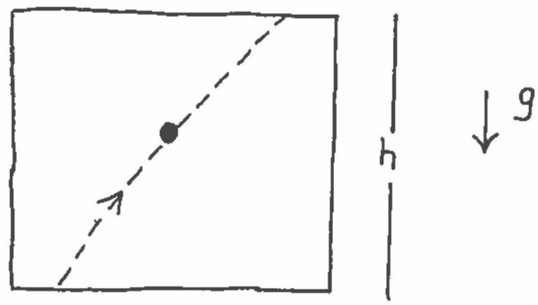
Problem 2 (25 points)

You are looking out your window, which has a height h and is located some distance above the ground. A friend on the ground tosses up a ball, which passes in front of the window along a curved path, as shown. Using a stopwatch, you find that it takes a time T for the ball to do this.



(a) What is V_{0y}, the ball's vertical speed when you first see it?

$h = -\frac{1}{2}gT^2 + V_{0y}T$

$h + \frac{1}{2}gT^2 = V_{0y}T$

$\boxed{\frac{h}{T} + \frac{g}{2}T = V_{0y}}$

$2h = gT^2 + 2V_{0y}T$

$2h + gT^2 + 2V_{0y}T$

$\frac{2h+gT^2}{2T}$

(b) How long after the ball passes above the window will it reach its maximum height?

$0 = -gt + V_{0y}$ ⇐ Max height when $V_y = 0$

$gt = V_{0y}$

$t = \frac{V_{0y}}{g}$

$t = \frac{2h + gT^2}{2T} \cdot \frac{1}{g}$

$t = \frac{2h + gT^2}{2Tg}$

The actual time after passing the window is actually $t - T$, which we will resolve as

$T_{actual} = \frac{2h + gT^2}{2Tg} - T$

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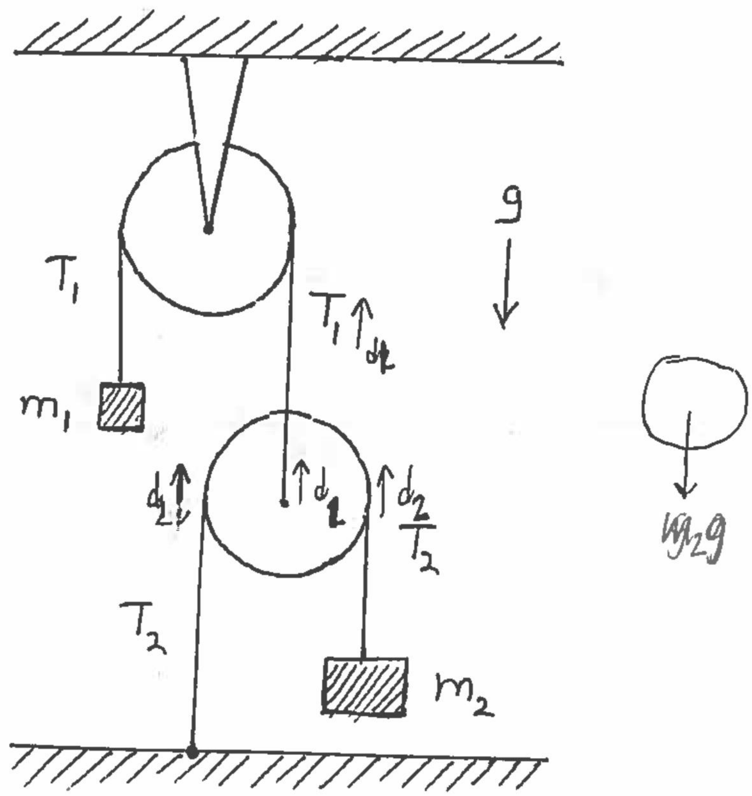
Problem 3 (25 points)

A massless, frictionless pulley is fixed to the ceiling. On one side of this pulley hangs a mass m_1. On the other side is a second, massless pulley, from which hangs a second mass, m_2. The string connected to m_2 passes over the lower pulley and is bolted to the floor. Let T_1 and T_2 be the tensions in the upper and lower strings, respectively. Also, let a_1 and a_2 be the accelerations of the two masses. Your goal in this problem is to find a_1.



(a) By considering the motion of the lower pulley, find a relationship between T_1 and T_2.

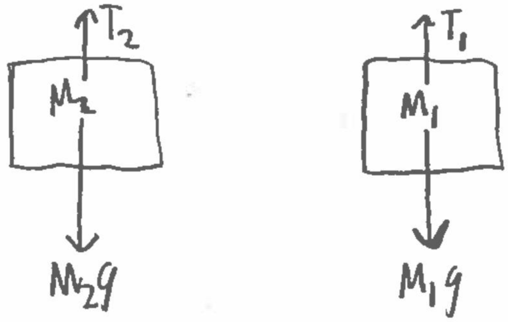
$\sum F_{P_2} = 0$ (massless pulley)

$\sum F_{P_2} = 2T_2 - T_1$ (Only forces acting on it)

$0 = 2T_2 - T_1$

$T_1 = 2T_2$

(b) Draw free-body diagrams for each mass. Thereby find two independent relationships that involve the accelerations and the masses.



$m_2 a_2 = m_2 g - T_2$

$m_2 a_1 = m_1 g - T_1$

$m_1 a_1 = m_1 g - 2T_2$

(c) You now have three equations for four unknowns: T_1, T_2, a_1, and a_2. Thus, you are missing a geometric constraint. What is it?

The distance of motion. For the bottom pulley to move a distance d_2, the top pulley must move rope $d_1 = 2d_2$.

Differentiate twice, and you get $\boxed{a_1 = 2a_2}$

(d) Find the ratio a_1/g in terms of m_1 and m_2.

$m_2 a_2 = m_2 g - T_2 \Rightarrow \frac{1}{2} m_2 a_1 - m_2 g = -T_2$

$m_1 a_1 = m_1 g - 2T_2 \qquad m_2\left(\frac{a_1}{2} - g\right) = -T_2$

$m_1 a_1 = m_1 g - m_2 a_1 - 2m_2 g$

$(m_1 + m_2) a_1 = (m_1 - 2m_2) g$

$$\boxed{\frac{a_1}{g} = \frac{m_1 - 2m_2}{m_1 + m_2}}$$

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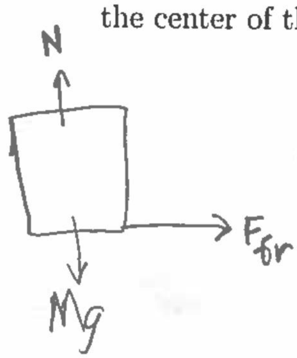
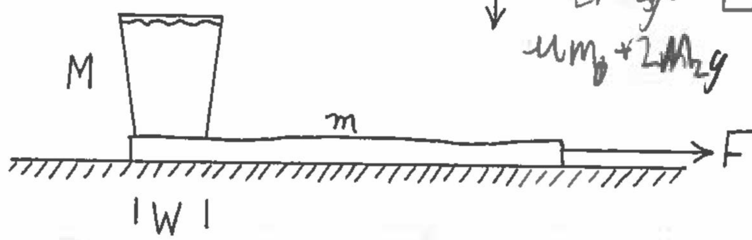
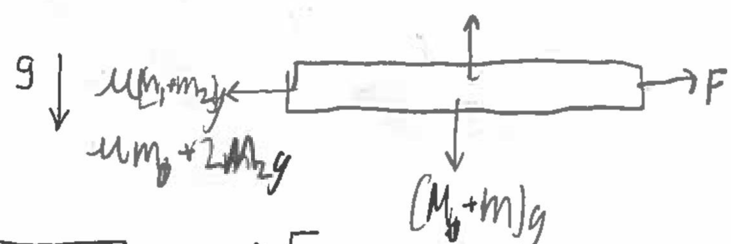
Problem 4 (30 points)

A glass full of water, with total mass M, rests on a thick cloth of mass m. The circular bottom of the glass has diameter W. The cloth lies on a flat, wooden table. Let μ be the coefficient of friction, both static and kinetic, between glass and cloth, and between cloth and wood.

At $t = 0$, the left ends of the ~~table~~ glass and cloth coincide, as shown. Starting at this time, you pull on the cloth with a steady, horizontal force F to the right, so that the cloth accelerates at rate a_0 and the glass slips behind. Once the left end of the cloth reaches the center of the glass bottom, water spills out.







(a) At what time t_s does water begin to spill?

$F_{Gr} = \mu Mg$

$\sum F_{cx} = F_{Gr}$

$Ma_c = F_{Gr}$

$Ma_c = \mu g M$

$a_c = \mu g$

Thus, the acceleration of cloth relative to cup is

$a_{rel} = a_0 - \mu g$

Plug into kinematics equations:

$\frac{1}{2}W = \frac{a_0 - \mu g}{2} t_s^2$

$\sqrt{\frac{W}{a_0 - \mu g}} = t_s$

(b) What is V_g, the horizontal speed of the glass at that time?

$V_g = 0 + a_c t_s$

$V_g = \mu g \sqrt{\frac{W}{a_0 - \mu g}} = \sqrt{\frac{W\mu^2 g^2}{a_0 - \mu g}}$

(c) How far along the table has the glass traveled by time t_s?

$x = \frac{\mu g}{2} t^2$

$x = \frac{\mu g}{2} \cdot \frac{W}{a_0 - \mu g}$

$x = \frac{W\mu g}{2a_0 - 2\mu g}$

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(d) For times $0 < t < t_s$, what is F?

$\sum F_{Cloth\,x} = F - F_{fr_T} - F_{fr_G}$

$ma_0 = F - (\mu M g + (m+M)g)$

$ma_0 = F - \mu g(m + 2M)$

$ma_0 + \mu g(m+2M) = F$

$F = ma_0 + \mu g m + 2\mu g M$

$\boxed{F = m(a_0 + \mu g) + 2\mu M g}$

$F_{fr_T} = \mu N \qquad N = (m+M)g$

$F_{fr_T} = \mu(m+M)g$

$F_{fr_g} = \mu N_g \qquad N_g = Mg$

$F_{fr_g} = \mu M g$

$\sum F_{cloth\,y} = mg + Mg - N$

$0 = mg + Mg - N$

$N = mg + Mg$

$N = (M+m)g$

Glass:

Cloth