Name:	Student ID Number:
Surname:	Exam Room:

KOÇ UNIVERSITY
College of Sciences
PHYS 101 General Physics 1
Fall Semester 2019
Final Exam
December 24, 2019 Tuesday, 18:15-20:05

Please read.

- Count to make sure that there are 5 pages in this question booklet
- Check your **name, number, on front page, and student ID on each page.**.
- This examination is conducted with closed books and notes.
- Put all your personal belongings underneath your seat and make sure that pages of books or notebooks are not open.
- Absolutely no talking or exchanging anything (like rulers, erasers) during the exam.
- You must show all your work to get credit; you will not be given any points unless you show the details of your work (this applies even if your final answer is correct).
- Write neatly and clearly; unreadable answers will not be given any credit.
- If you need more writing space, use the backs of the question pages and put down the appropriate pointer marks.
- You are not allowed to use calculators during this exam.
- You are not allowed to leave the class during the first 15 minutes, and last 15 minutes.
- Write your final answers into the boxes. No points will be given to unjustified answers. Incomplete calculations will not be graded.

I hereby certify that I have completed this exam on my own without any help from anyone else.

Signature

P101_Index:

1	2	3	4	Total

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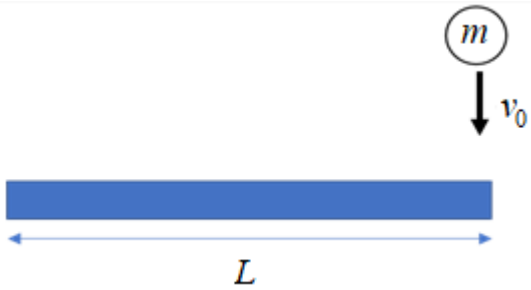
Q1-(25 pts) A point mass m is sliding across a frictionless horizontal surface at speed v_0. It collides with a uniform rod of mass m and length L at its tip and attaches to it. (Note that the rod is completely free to move, $I_{\text{rod-cm}}=ML^2/12$)



(a) Which physical quantity or quantities are conserved during this collision? (5 pts)

(b) What is the moment of inertia of the combined object around its center of mass? (5 pts)

(c) What is the center of mass velocity and angular velocity of the combined object after the collision? Show the direction of angular velocity. (10 pts)

(d) What is the kinetic energy of the system after the collision? (5 pts)

Solution continues on the back side of the page **Yes** □ **No** □

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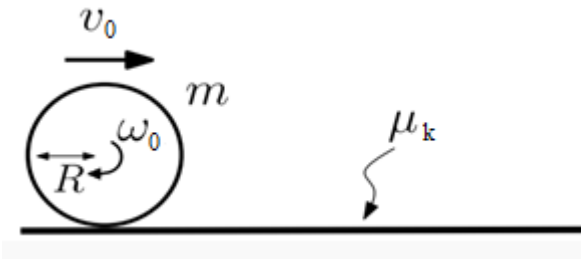
Q2-(25 pts) Consider a ball of mass m and radius R that is rolling with slipping on a flat surface with a kinetic friction coefficient μ_k. At $\boldsymbol{t = 0}$ its center of mass moves to the right with speed v_0 and it rotates clockwise with angular speed ω_0. At $t = T$ the ball starts rolling without slipping. You may neglect the static friction, and use $I_{CM} = 2mR^2/5$.
Assuming $\omega_0 < v_0/R$,



(a) draw the free body diagram for the ball when it is rolling with slipping ($0 \leq t < T$).

(b) apply the dynamic (Newton's law and torque) equations and find T.

(c) find the displacement of the ball between $t = 0$ and $t = T$.

(d) Now assume $\omega_0 > v_0/R$, and draw the free body diagram for the ball when it is rolling with slipping ($0 \leq t < T$).

Solution continues on the back side of the page **Yes** □ **No** □

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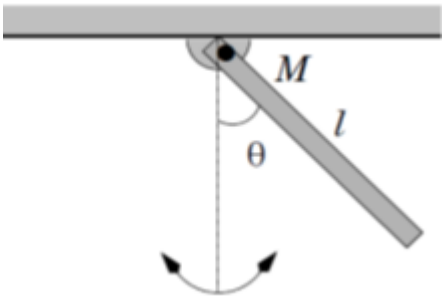
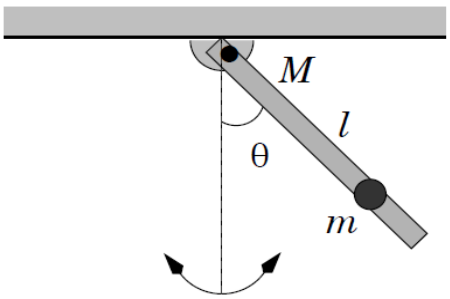
Q3-(25 pts) A uniform rod with mass *M* and length *l* is hanged from a pivot.



(a) Drive the equation of motion and find the oscillation frequency for small angles. (10 pts) ($I_{rod\text{-}cm}=ML^2/12$)

(b) Later a point mass m is attached to the rod. At what point on the rod it should be attached so that the frequency of the oscillations remains the same? (15 pts)



Solution continues on the back side of the page **Yes** □ **No** □

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Q4-(25 pts) Consider the Kepler's problem for the planetary motion in the *xy* plane.

(a) Write down the mathematical expression that describes the Kepler's law of orbits, and sketch it on an *xy* coordinate system.

(b) Describe the Kepler's law of areas, and discuss what is the physical principle behind it.

(c) State the Kepler's law of periods, and derive it for a circular orbit.

Solution continues on the back side of the page **Yes** □ **No** □