MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Physics

Physics 8.01 Fall 2000

EXAM 3
Monday, November 20, 2000

FAMILY (Last) NAME

GIVEN (First) NAME

Student ID Number

Your Recitation (check one) →

R01	MW 1:00	W. Bertozzi	
R02	MW 2:00	W. Bertozzi	
R03	MW 3:00	W. Bertozzi	
R12	TR 1:00	A. Bolton	
R18	TR 9:00	B. Burke	
R19	TR 10:00	B. Burke	
R20	TR 11:00	B. Burke	
R21	TR 2:00	M. Evans	
R22	TR 3:00	M. Evans	
R06	MW 2:00	M. Feld	
R07	MW 3:00	M. Feld	
R08	MW 4:00	M. Feld	
R16	TR 11:00	D. Fernie	
R15	TR 10:00	A.Guth	
R23	TR 11:00	J. Hager	
R24	TR 12:00	J. Hager	
R09	MW 1:00	P. Joss	
R10	MW 2:00	P. Joss	
R11	MW 3:00	P. Joss	
R26(M)	TR 3:00	McBride/Bove	
R17	TR 12:00	TA- Ribeiro	
R13	TR 2:00	J. Shelton	
R14	TR 3:00	J. Shelton	
R04	MW 1:00	G. Stephans	
R05	MW 2:00	G. Stephans	

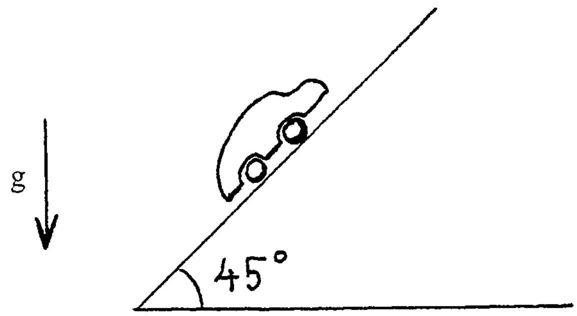
Instructions:

1. SHOW ALL WORK. All work must be done in this booklet. Extra blank pages are provided.
2. ***Formula sheets are in the back of this exam. You may tear them off.***
3. This is a closed book exam.
4. <u>CALCULATORS</u>, BOOKS, and NOTES are
5. NOT ALLOWED.
6. Do all FOUR (4) problems.
7. Exams will be collected 5 minutes before the hour.

Problem	Maximum	Score	Grader
1	25		
2	25		
3	25		
4	25		
TOTAL	100		

Note: this exam included a 6-page formula sheet, which can be downloaded separately.

1. a) (9 points, no partial credit)



$\cos 45° = \sin 45° = \frac{1}{\sqrt{2}}$
$\tan 45° = 1$

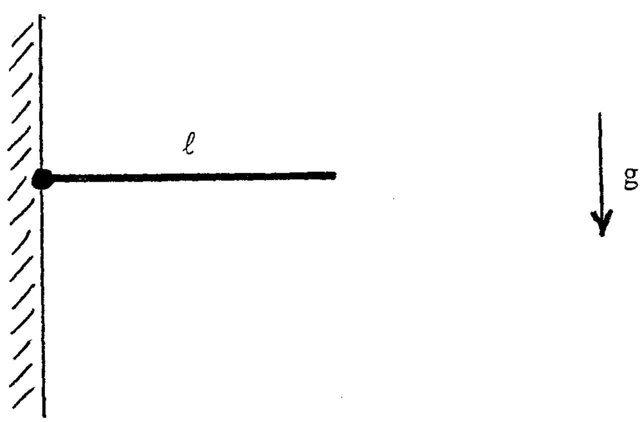
If the coefficients of static and kinetic friction between the tires and the road are μ_s and μ_k, the maximum acceleration that a car can have going up a 45° slope is:

i) $\frac{g}{\sqrt{2}}(1-\mu_k)$ ii) $\frac{g}{\sqrt{2}}(1-\mu_s)$ iii) $\frac{g}{\sqrt{2}}(1+\mu_k)$ iv) $\frac{g}{\sqrt{2}}(1+\mu_s)$

v) $\frac{g}{\sqrt{2}}(\mu_k-1)$ vi) $\frac{g}{\sqrt{2}}(\mu_s-1)$ vii) $g(\mu_k-1)$ viii) $g(\mu_s-1)$

ix) $g(1-\mu_s)(1-\mu_k)$ x) Can be any value provided the engine is strong enough

b) (8 points, no partial credit)



A uniform rod of length ℓ is attached to a wall with a frictionless hinge. The rod is released from rest when it is horizontal. The angular velocity of the rod at the instant it hits the vertical wall is:

i) $\frac{3}{2}\frac{g}{\ell}$ ii) $\sqrt{\frac{3g}{2\ell}}$ iii) $\frac{3g}{\ell}$ iv) $\sqrt{\frac{3g}{\ell}}$ v) $\frac{6g}{\ell}$

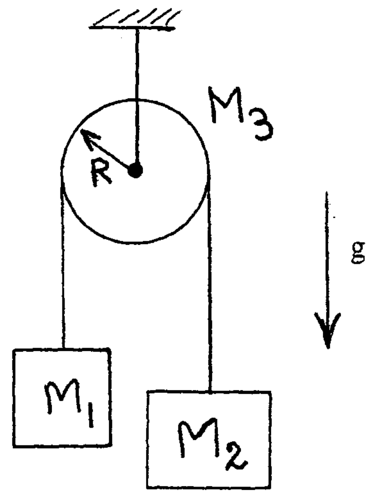
vi) $\sqrt{\frac{6g}{\ell}}$ vii) $\frac{12g}{\ell}$ viii) $\sqrt{\frac{12g}{\ell}}$

c) (8 points, no partial credit)

At an instant when a figure skater is spinning with angular velocity ω about a vertical axis, her moment of inertia, about the same axis is I_1. She then moves out her arms and increases her moment of inertia about the same axis to a value I_2. Her new angular velocity is:

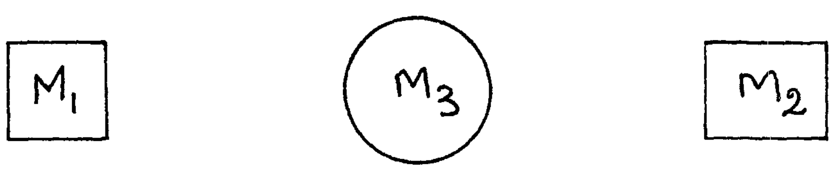
i) ω ii) $\frac{I_1}{I_2}\omega$ iii) $\frac{I_2}{I_1}\omega$ iv) $\frac{I_1^2}{I_2^2}\omega$ v) $\frac{I_2^2}{I_1^2}\omega$

vi) $\frac{I_2 - I_1}{I_2 + I_1}\omega$ vii) $\frac{I_2 + I_1}{I_2 - I_1}\omega$ viii) $\sqrt{\frac{I_1}{I_2}}\,\omega$ ix) $\sqrt{\frac{I_2}{I_1}}\,\omega$



2. (25 points)

Two masses M_1 and M_2 ($M_2 > M_1$) are connected by a massless string over a massive pulley as shown above. The pulley consists of a uniform cylinder of radius R and mass M_3. It is supported by a frictionless axle. The string does not slip on the pulley. On the pictures below, draw free body diagrams for each object in the system.



— *Problem 2 is continued on next page* —

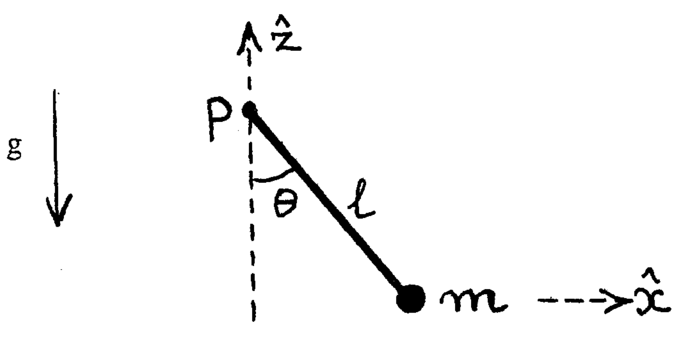
In the 4 boxes below, write down a complete set of independent equations, which when solved would give the magnitude of the acceleration of the two masses. Do not solve the equations. You must define all the symbols you use on the free body diagrams above.

Note: Write no more than one independent equation per box.

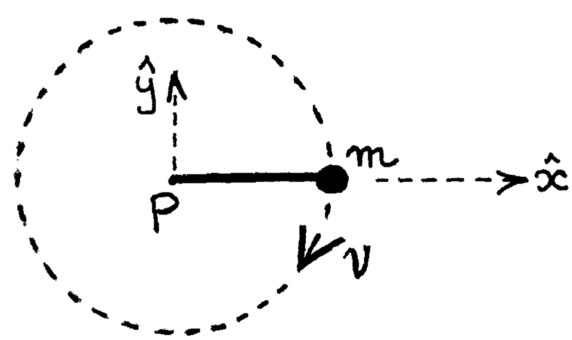
3. (25 points). A conical pendulum consists of a small heavy sphere of mass m attached to a string of length ℓ and negligible mass. The string makes an angle θ with the vertical and the sphere describes a circular path with constant speed v, in the direction shown in B. P is the point of suspension.

   Use a coordinate system with z vertically up and x to the right.

   Looking from the side (A)



   Looking from above (B)



— Problem 3 is continued on next page —

At an instant when the pendulum is in the x-z plane (see Figures), in terms of <u>only</u> m, ℓ, θ, v, and g:

a) i) What is the magnitude of the angular momentum L_z about the z-axis?

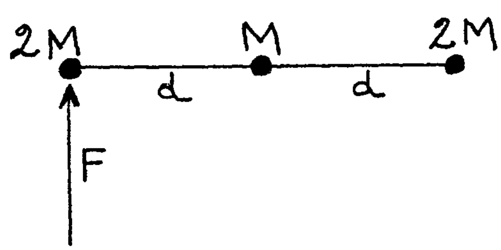
ii) What is the magnitude of the net torque exerted on the pendulum about this axis?

b) i) What is the magnitude of the angular momentum $\vec{\mathbf{L}}_P$ of the sphere with respect to the point P at the instant pictured?

ii) On the appropriate diagram above, with an arrow, indicate as well as you can the direction of $\vec{\mathbf{L}}_P$.

iii) What net vector torque $\vec{\boldsymbol{\tau}}$ is exerted about the point P?

4. (25 points). Three small spheres of mass M and $2M$ as shown are connected by two massless rigid rods, each of length d. They are placed on a frictionless horizontal table. At time $t = 0$, a horizontal force of magnitude F is applied to the $2M$ mass on the left. It is applied in a direction perpendicular to the rod as shown below. Initially all masses are stationary.



Top View

What is the magnitude of the instantaneous linear acceleration of <u>each</u> mass immediately after the force is applied. Your answer must be in terms of <u>only</u> F, M, and d.