Ph 205 2ND MID TERM EXAM

DUE IN CLASS 10:30 AM, TUESDAY, DEC 8, 1981

THIS IS A TAKE-HOME EXAM

TIME LIMIT = 90 MINUTES IN ONE CONTINUOUS SITTING

THE EXAM IS CLOSED BOOK, CLOSED NOTES.

THE EXAM CONSISTS OF 3 PROBLEM WORTH, 6, 8, & 16 POINTS.
THE EXAM COVERS THE COURSE MATERIAL FROM GRAVITATION THRU ROTATIONS.

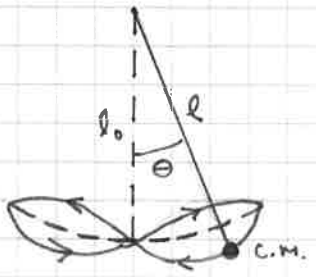
PLEASE DO ALL WORK YOU WISH GRADED IN THE EXAM BOOKLET PROVIDED.

THE PROBLEMS CAN BE WORKED IN MORE THAN ONE WAY. REFLECT A BIT BEFORE CHOOSING YOUR METHOD.

① (6 POINTS) A SATELLITE IS IN A CIRCULAR ORBIT ABOUT THE EARTH WHICH LIES WITHIN THE UPPER ATMOSPHERE. HENCE IT EXPERIENCES A DRAG FORCE $\bar{F} = -\alpha \bar{v}$. THE ORBIT REMAINS ESSENTIALLY CIRCULAR AT ALL TIMES AS α IS SMALL. FIND $v(t)$ AND $r(t)$ IF $r = r_0$, $v = v_0$ WHEN $t = 0$.

r = DISTANCE OF SATELITTE FROM THE CENTER OF THE EARTH.

② (8 POINTS) <u>THE SWING</u>. IN PUMPING A SWING, A PERSON RAISES AND LOWERS HIS OR HER C.M. APPROXIMATELY ACCORDING TO $\ell = \ell_0 (1 + \epsilon \sin 2\omega_0 t)$ WHERE $\omega_0 = \sqrt{\frac{g}{\ell_0}}$ AND ϵ IS SMALL.



WE EXPECT THE MOTION TO BE OSCILLATIONS OF EVER INCREASING AMPLITUDE:

$$\theta(t) \sim a(t) \cos \omega_0 t$$

WHERE $a(t)$ VARIES SLOWLY IF ϵ SMALL.

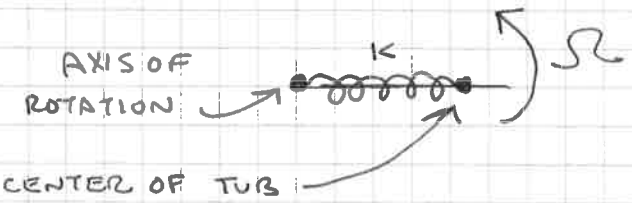
FIND AN APPROXIMATE EXPRESSION FOR $a(t)$.

MAKE A NUMERICAL ESTIMATE OF THE TIME REQUIRED TO TRIPLE THE AMPLITUDE FOR A REALISTIC SWING.

③ (16 POINTS) <u>PHYSICS IN THE LAUNDROMAT</u>

IF A WASHING MACHINE IS UNEVENLY LOADED, VIOLENT MOTIONS CAN OCCUR AT THE START OF THE SPIN CYCLE. NONETHELESS AS THE SPIN VELOCITY INCREASES A STABLE MOTION (USUALLY) RESULTS.

THE MECHANISM OF THE WASHING MACHINE IS SOMETHING LIKE THE FOLLOWING. THE CENTER OF THE WASH TUB IS NOT NECESSARILY ON THE AXIS OF ROTATION, BUT IS TIED TO THE AXIS BY A SPRING OF CONSTANT K. (REST LENGTH ZERO)



THE CENTER OF THE TUB IS CONSTRAINED TO ROTATE ABOUT THE AXIS OF ROTATION WITH ANGULAR VELOCITY Ω = CONSTANT.

FOR EXAMPLE, THE CENTER OF THE TUB MIGHT SLIDE ALONG A ROD WHICH ROTATES WITH Ω.

BECAUSE OF THE UNEVEN LOAD, THE C.M. OF THE TUB IS NOT AT THE CENTER OF THE TUB BUT A DISTANCE a AWAY.

THE TUB CAN ROTATE ABOUT ITS CENTER, SO THERE IS NO CONSTRAINT ON θ. ALL ROTATIONS TAKE PLACE IN THE SAME PLANE.

a) WHAT ARE THE EQUILIBRIUM VALUES OF θ AND Y = DISTANCE FROM AXIS TO CENTER OF TUB? LET M = MASS OF TUB AND LOAD.

SUPPOSE $\Omega > \omega_0 \equiv \sqrt{K/M}$ (IMAGINE ALL MASS CONCENTRATED AT THE C.M. FOR SIMPLICITY)

b) SHOW THAT THE EQUILIBRIUM IN Y IS UNSTABLE IF $\theta = \theta_{EQUILIBRIUM}$ ALWAYS.

c) SHOW THAT THE EQUILIBRIUM IS STABLE IF θ IS FREE TO VARY. WHAT IS THE FREQUENCY OF SMALL OSCILLATIONS IN THE LIMIT $\Omega \to \infty$? WHAT IS THE MOTION OF THE C.M. IN THIS LIMIT?