Copyright statement

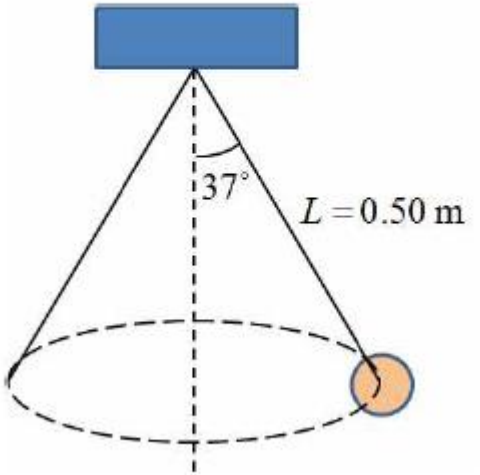
- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8^{th} and 9^{th} Ed.
- The rest is made by me.

2012년 2차 시험

Problem 1. (25 points) An object hanged on a rope $L = 0.50$ m does rotational motion. If the angle between rope and vertical axis is $37°$.

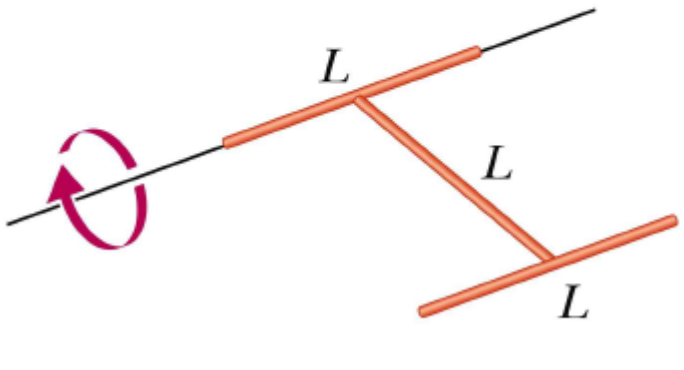
(a) Find the tangential velocity of the object.

(b) How long does it take to complete one full rotation?



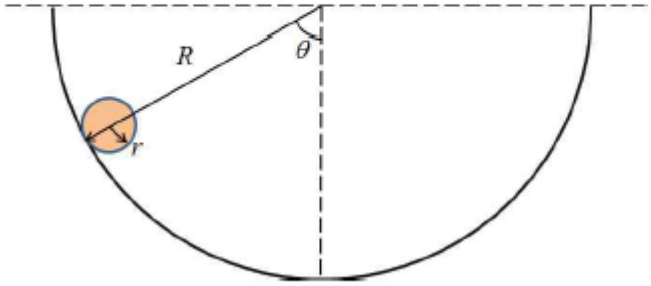
<Fig. 1>

Problem 2-A. (25 points) A rigid body is made of three identical thin rods, each with length $L = 0.50$ m, fastened together in the form of a letter **H**. The body is free to rotate about a horizontal axis that runs along the length of one of the legs of the **H**. The body is allowed to fall from rest from a position in which the plane of the **H** is horizontal. What is the angular speed of the body when the plane of the **H** is vertical?



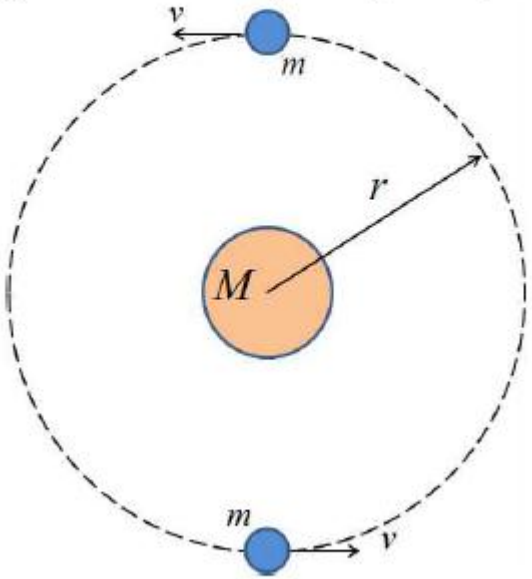
<Fig. 3-A>

Problem 2-B. (25 points) A uniform solid sphere of radius r is placed on the inside of a hemispherical bowl of radius R. The sphere is released from rest at an angle θ with respect to the vertical, as shown in Fig. 2-B. If the sphere rolls without slipping, find the speed of its center of mass as it rolls through the bottommost point of the bowl.



<Fig. 2-B>

Problem 3. (25 points) A pair of two identical planets having mass m are circling around a star having mass M with a constant velocity v as shown in Fig. 3. The three-body system is co-linear. (a) Find an expression for v in terms of given parameters (radius r, gravitational constant G, M, and m). (b) What is the period of rotation? (c) What will be the escape velocity for the pair?

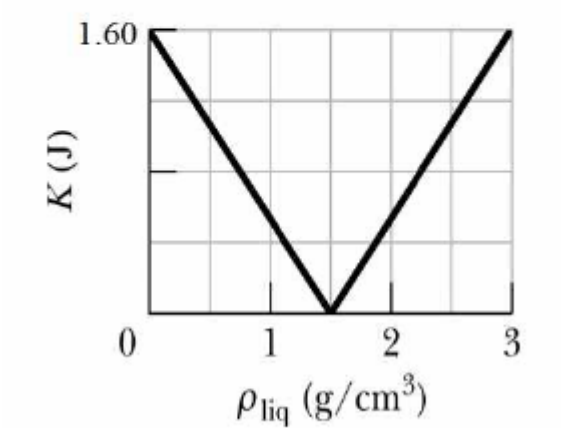


<Fig. 3>

Problem 4. (25 points) A small solid cube is released from rest while fully submerged in a liquid, and then its kinetic energy K is measured when it has moved 4.0 cm in the liquid. Then, K is plotted with respect to the liquid density ρ_{liq} (Fig. 4 gives the results after many liquids are used).

(a) What are the density ρ_{cube} and the volume of the cube?

(b) When the cube finds its static equilibrium position on the surface, what fraction (%) of the cube will be submerged in the liquid if $\rho_{liq} = 3.0\ \mathrm{g/cm^3}$? [Assume that the cube translates only vertically without any rotation.]



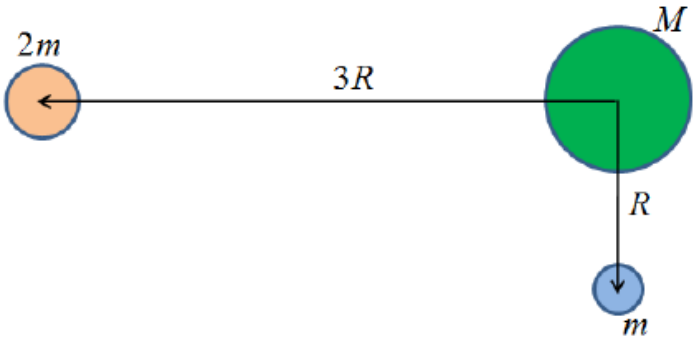
<Fig. 4>

2011년 2차시험

Problem 1. (15 points) The two communication satellites (mass m and $2m$) have circular orbits of the radii R and $3R$, respectively, about the Earth (mass M). Gravitational constant is G. Ignore the interaction between the two satellites.

(a) Find the ratio, (kinetic energy of mass $2m$)/(kinetic energy of mass m).

(b) Plot the mechanical energy curves of the two satellites in one graph as a function of the parameter R.



<Fig. 1>

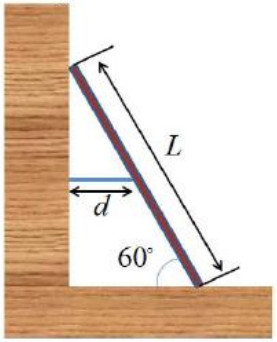
Problem 2-A. (30 points) A uniform ladder (length L and mass M) leans against a frictionless wall at an angle of 60° on a frictionless floor. A massless rope (length d) horizontally connects the ladder to the wall.

(a) Draw all the forces acting on the ladder.

(b) Write down equations for the system based on Newton's 2nd law.

(c) Find the tension on the rope.

(d) Find the force of the ground on the ladder.



<Fig. 2-A>

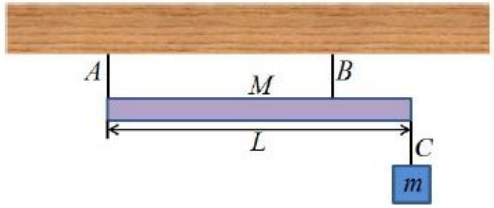
Problem 2-B. (30 points) A uniform bar (length L and mass M) hangs horizontally by two ropes (the rope A at the end and the rope B at $\frac{3}{4}L$ apart position). At the other end of the bar, a box of mass m hangs by a massless rope C.

(a) Draw all the forces acting on the bar.

(b) Find the tension on the rope C.

(c) Write down equations for the system based on Newton's 2nd law.

(d) Find the tensions on the two ropes A and B.



<Fig. 2-B>

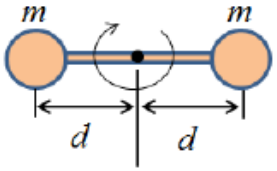
Problem 3. (30 points) In two rotation systems (A and B), two balls (each with mass m) are attached to a massless rod whose length is $2d$ and $4d$ in A and B, respectively. The two balls can freely rotate about the axis through its center in a plane. The rotation axis in A is parallel to that in B. Initially balls in A rotate with an angular speed ω and do not touch balls in B when the system B does not rotate. At one moment, a ball in A made an elastic collision with a ball in B, as shown in Fig. 3. Right after the collision, the system A and B have the angular speeds ω_1 and ω_2, respectively.

(a) Find the ratio (moment of inertia of B)/(moment of inertia of A).

(b) Write down the relation between kinetic energies before and after the collision.

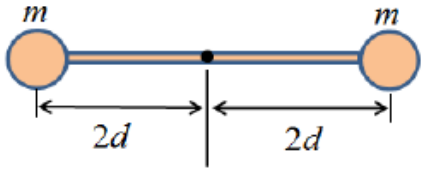
(c) Write down the relation between angular momenta before and after the collision.

(d) Calculate the angular speeds ω_1 and ω_2 in terms of ω.



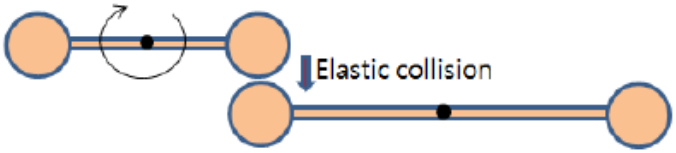
System A

<Fig. 3-1>



System B

<Fig. 3-2>



<Fig. 3-3>

Problem 4. (25 points) A person of mass m gets on the rear part of a long uniform boat (mass M, length L) which was located at a dock, and then walks to the front part of the boat. The person walks at a speed v with respect to the dock before getting on the boat, and afterwards, walks at the speed $\frac{v}{2}$ with respect to the boat. The boat can slide through the water without significant resistance.

(a) Find the velocity of the boat right after the person stepped on to the boat.

(b) Find the distance between the dock and the center of mass of the system consisted of the boat and person right after the person getting on the boat.

(c) Find the distance between the dock and the person when he arrives at the front part of the boat.

<Fig. 4-1>

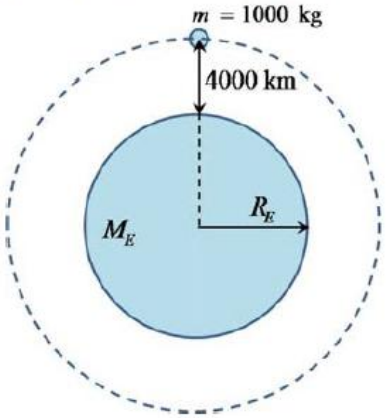
<Fig. 4-2>

2010년 문제

문제 1. (20점) 그림 1과 같이 지표면에서 고도 4000 km 높이에 질량 1000 kg인 인공위성이 원궤도를 돌고 있다. 지구의 반지름은 $R_E = 6000$ km이고 질량은 $M_E = 6 \times 10^{24}$ kg이며 만유인력 상수는 $G = 6 \times 10^{-11}\ \mathrm{m^3/kg \cdot s^2}$이다. 지구에서 무한히 멀리 떨어진 곳에서 퍼텐셜 에너지는 0이다. ($2\pi = 6$으로 근사한다.)

(a) 이 위성의 역학에너지를 구하시오.

(b) 위성이 지구를 한 바퀴 도는데 걸리는 시간을 구하시오.

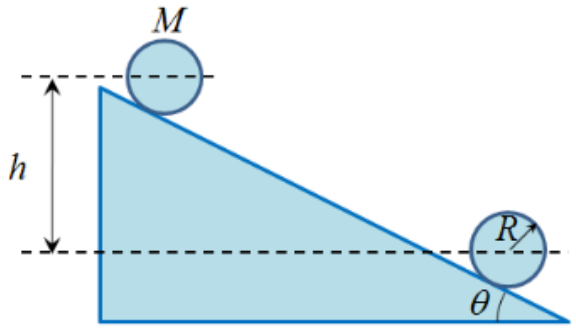


<그림 1>

문제 2. (30점) 그림 2와 같이 각이 θ인 경사면 위에서 멈춰 있던 원기둥이 미끄러지지 않고 수직 높이 h만큼 굴러 내려왔다. 원기둥은 질량 M이 균일하게 채워져 있고 반지름은 R이다. 중력가속도는 g이다. 원기둥의 회전관성은 $\frac{1}{2}MR^2$이다.

(a) 원기둥이 굴러 내려온 후 중심의 속도를 구하시오.

(b) 원기둥이 굴러 내려오는 동안 중심의 가속도를 구하시오.

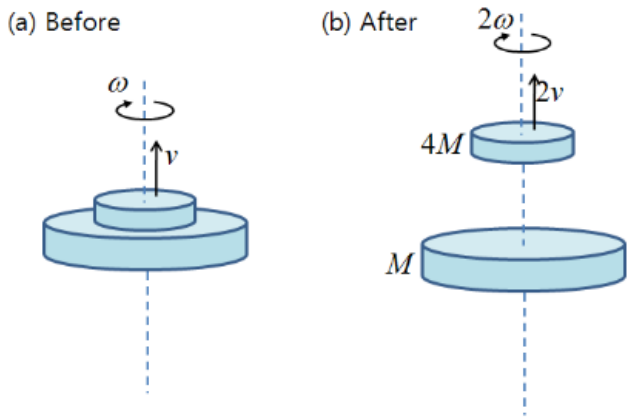


<그림 2>

문제 3. (30점) 그림 3과 같이 각각 반지름 $\frac{1}{2}R$과 R인 두 원판이 붙어서 원판과 수직한 축을 기준으로 각속도 ω로 회전하면서 원판과 수직한 축 방향으로 v의 속도로 등속도 운동하고 있다. 반지름이 작은 원판의 질량은 $4M$, 반지름이 큰 원판의 질량은 M이다. 두 원판 사이의 상호작용에 의해 두 원판이 분리되었는데 분리 후 작은 원판의 각속도는 2ω이고 속도는 $2v$였다. (중력은 무시한다.)

(a) 분리 후 큰 원판의 속도를 구하시오.

(b) 분리 전과 후 계의 역학에너지 변화를 구하시오..

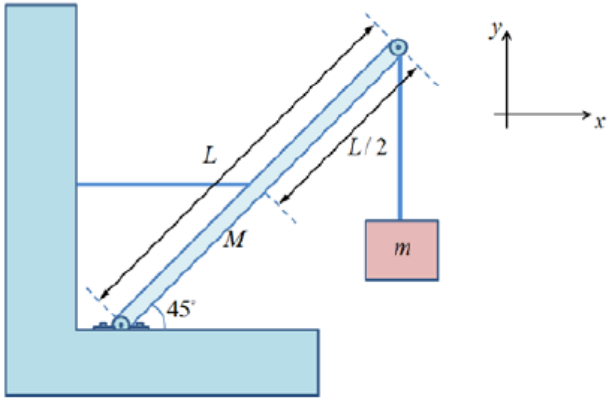


<그림 3>

문제 4. (20점) 그림 4와 같이 경첩으로 바닥에 고정된 버팀목이 질량이 없는 실을 통해 벽에 고정되어있고 또 다른 실 끝에는 질량 m이 매달려 있다. 버팀목의 길이는 L이고 질량은 M이며 기울어진 각도는 45°이다. 중력가속도는 g이고 계는 평형상태이다.

(a) 벽에 연결된 실에 걸리는 장력을 구하시오.

(b) 경첩에 걸리는 힘을 구하시오.



<그림 4>