N O T E

Free-Body Diagrams Revisited – II

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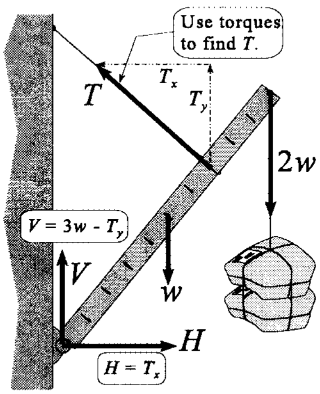
[Editor's Note: *We reproduce here a continuation of the collection of free-body exercises sent us by Jim Court, the first part of which was published in October. At the request of Jim's widow, a colleague and friend of the author, Paul Hewitt (One San Antonio Place – 2D, San Francisco, CA 94113-4032), is acting as Jim's representative in this important contribution to the teaching of physics.***]**

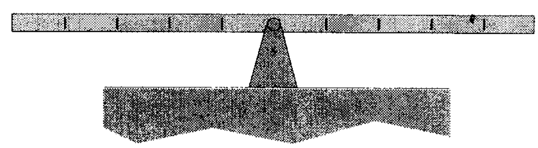
Free-Body Exercises: Rotational Equilibrium

All of the beams and the packages have the same weight w, and they are "uniform," which means the weight can be applied at the center. These systems are in equilibrium, so the net torque, the net vertical force and the net horizontal force are all zero. Symbols: w = weight, T = tension, n = normal reaction force at surface, V = vertical reaction force at hinge, H = horizontal reaction force at hinge, f = friction. RE-1 is done as an example.

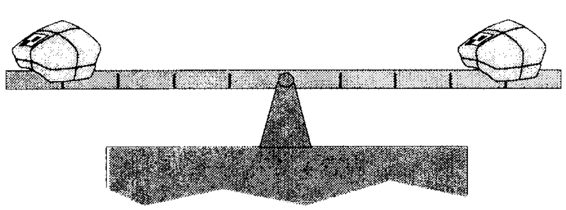
RE-1. Equilibrium



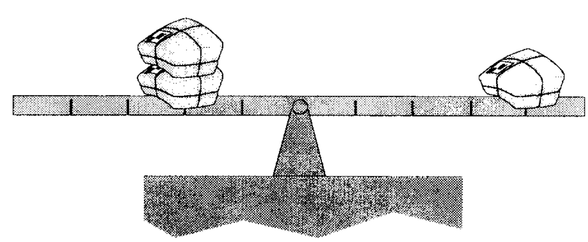
RE-2. Equilibrium



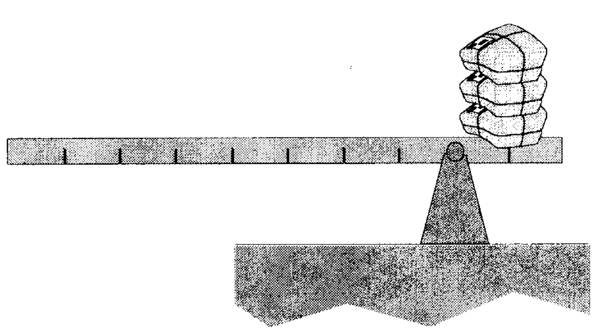
RE-3. Equilibrium



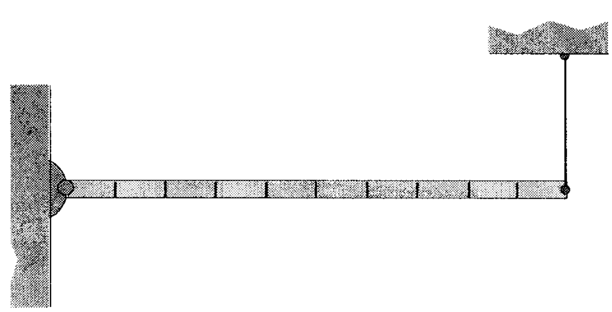
RE-4. Equilibrium



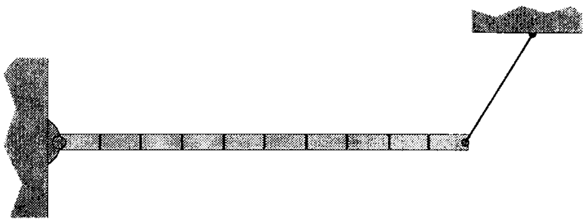
RE-5. Equilibrium



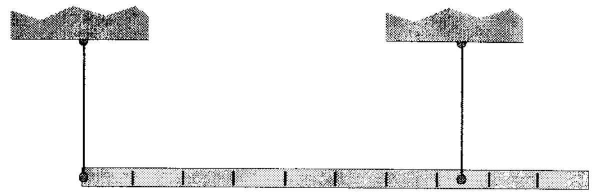
RE-6. Equilibrium



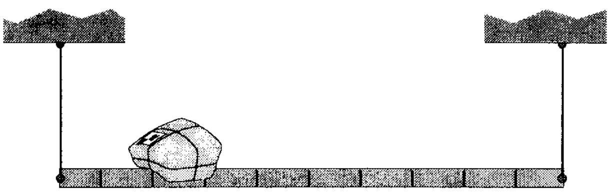
RE-7. Equilibrium



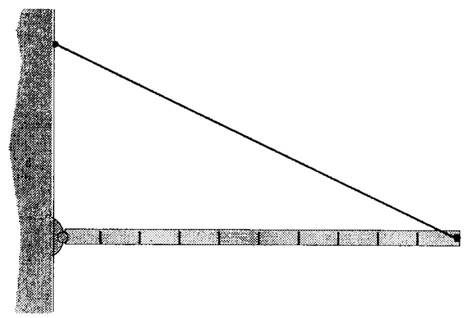
RE-8. Equilibrium



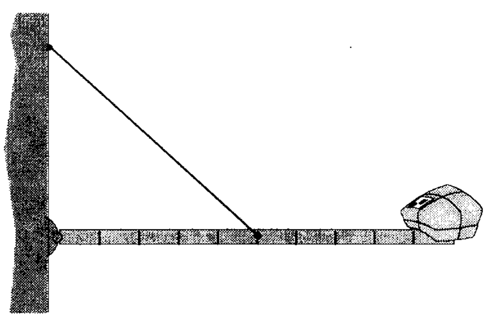
RE-9. Equilibrium



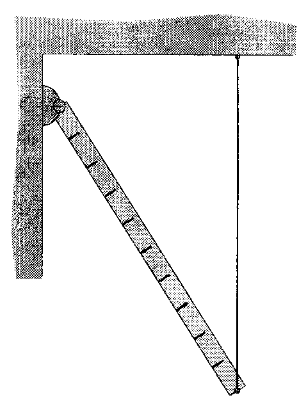
RE-10. Equilibrium



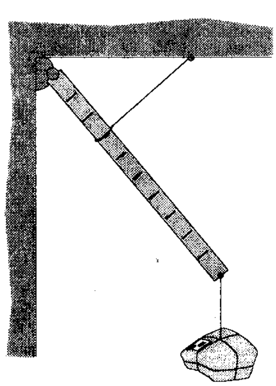
RE-11. Equilibrium



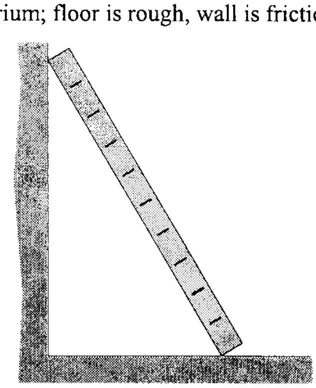
RE-12. Equilibrium



RE-13. Equilibrium



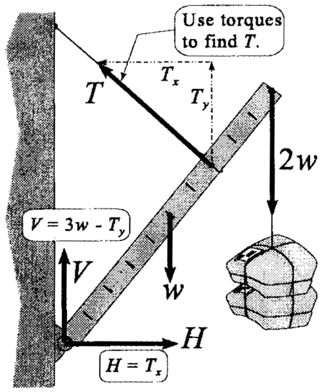
RE-14. Equilibrium; floor is rough, wall is frictionless.



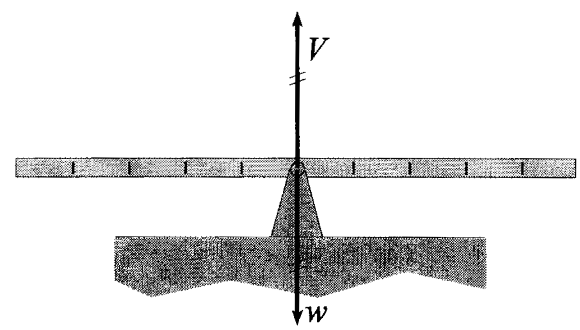
Free-Body Solutions: Rotational Equilibrium

Symbols: w = weight, T = tension, n = normal reaction force at surface, V = vertical reaction force at hinge, H = horizontal reaction force at hinge, f = friction.

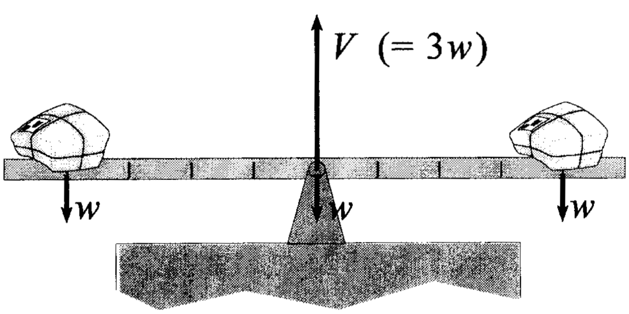
RE-1



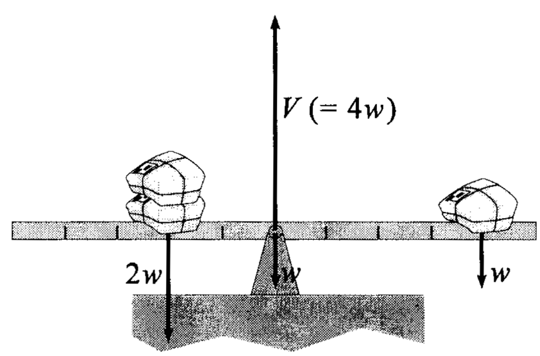
RE-2



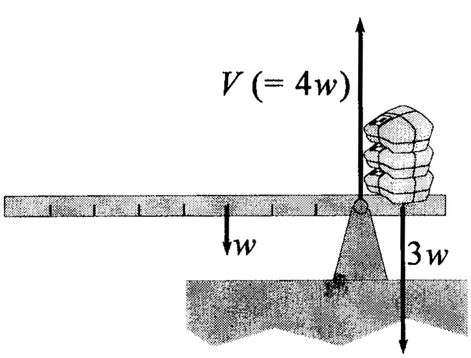
RE-3



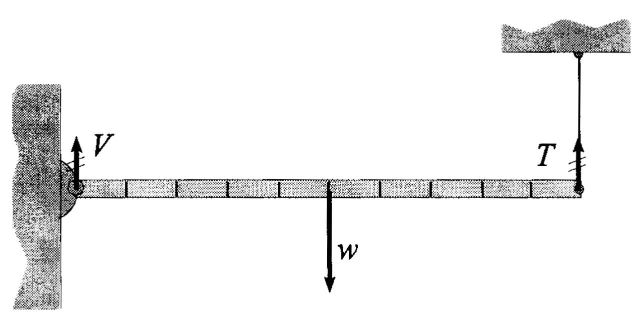
RE-4



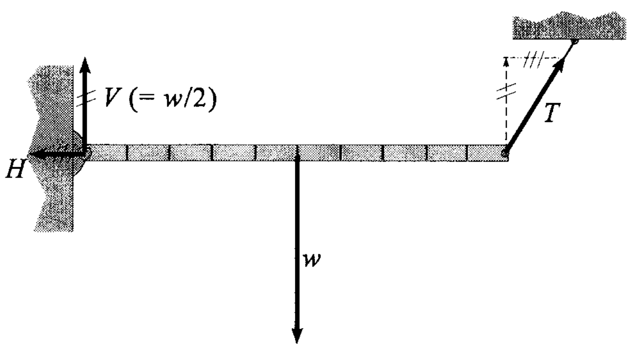
RE-5



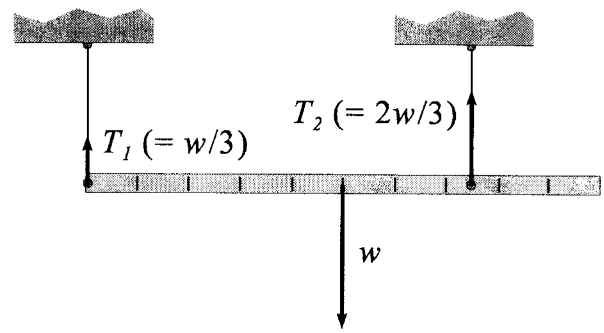
RE-6



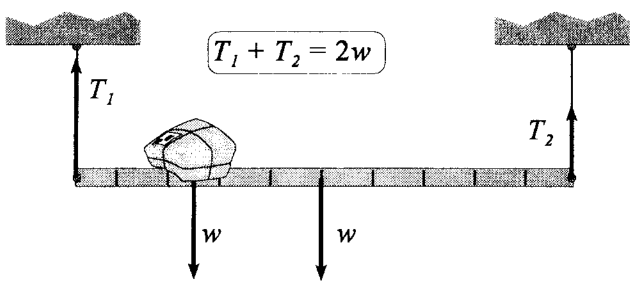
RE7



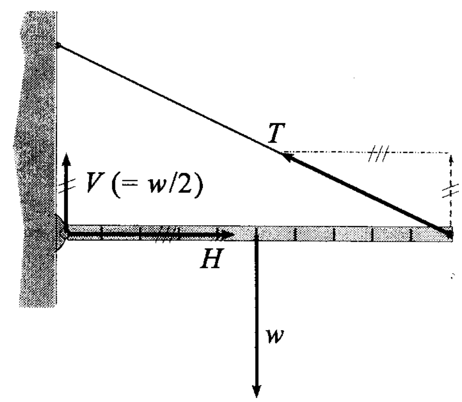
RE-8



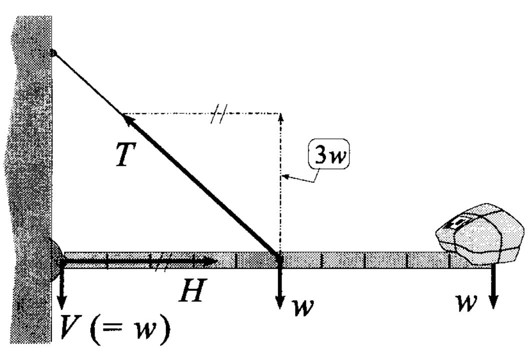
RE-9



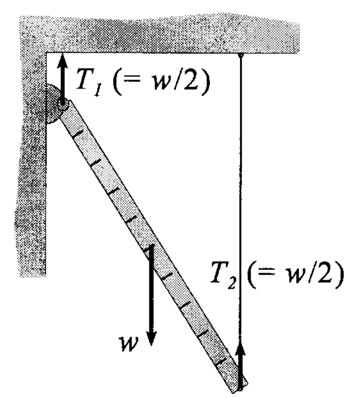
RE-10



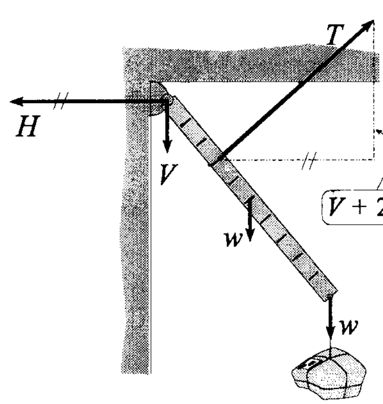
RE-11



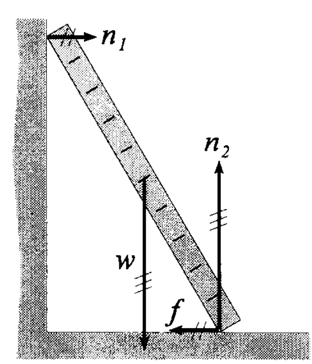
RE-12.



RE-13



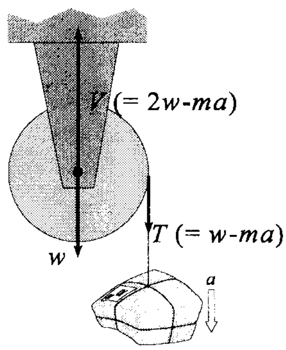
RE-14



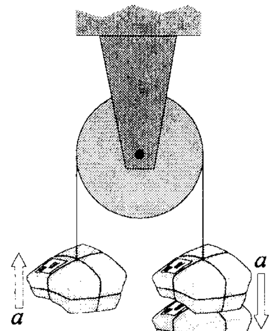
Free-Body Exercises: Rotational Non-equilibrium

In each case, draw arrows representing all forces acting on the cylinder or the beam. The solid, uniform cylinders, the packages suspended from them, and the uniform beams all have the same weight w. In all but one of these examples the object is not in rotational equilibrium, i.e. the torques do not add up to zero. Symbols: T = tension, w and m = weight and mass of cylinders, beams and packages, n = normal reaction force at surface, V = vertical force at hinge or axle, H = horizontal force at hinge, a = acceleration. RN-1 is done as an example.

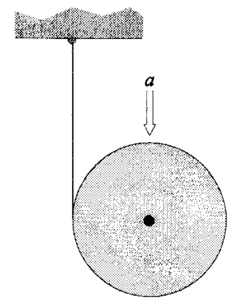
RN-1. Cylinder is supported on a frictionless horizontal axle.



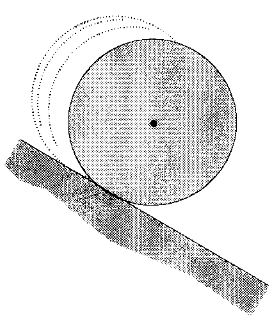
RN-2. Same as RN-1.



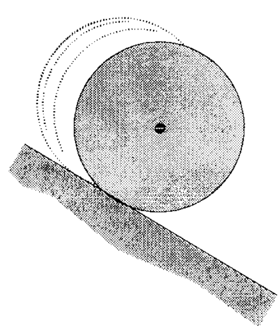
RN-3. String is tied to ceiling and wrapped around cylinder. Cylinder is falling.



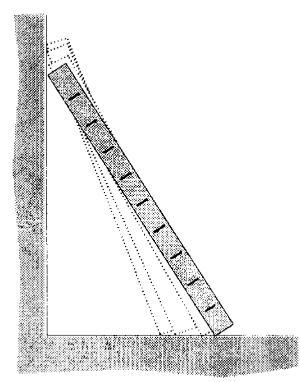
RN-4. Cylinder is rolling down a rough (not frictionless) incline.



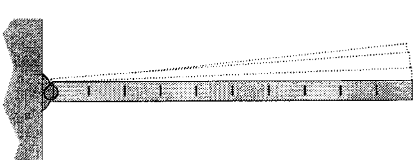
RN-5. Cylinder was released with zero angular velocity on a frictionless incline. Is it rolling?



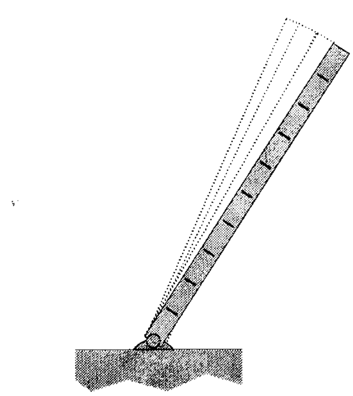
RN-6. Beam is slipping. Both wall and floor are frictionless.



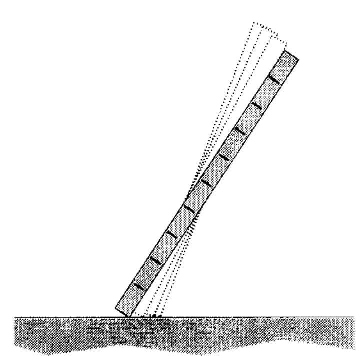
RN-7. Beam is swinging down through horizontal position.



RN-8. Beam is swinging downward.



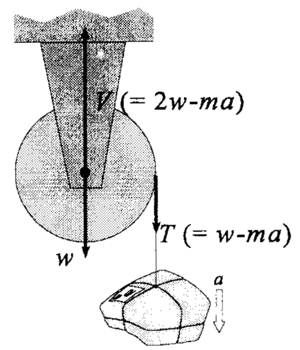
RN-9. Beam is falling on a smooth (frictionless) floor. If the beam is released from rest, what path does the c of m take?



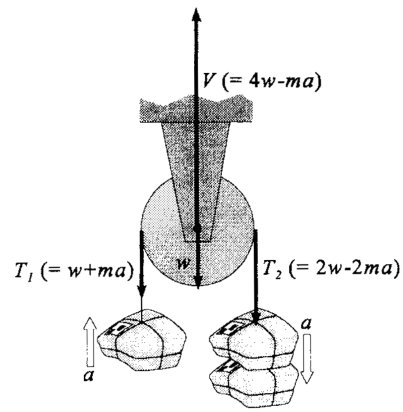
Free-Body Solutions: Rotational Non-equilibrium

Symbols: T = tension, w and m = weight and mass of cylinders, beams and packages, n = normal reaction force at surface, V = vertical force at hinge or axle, H = horizontal force at hinge, a = acceleration.

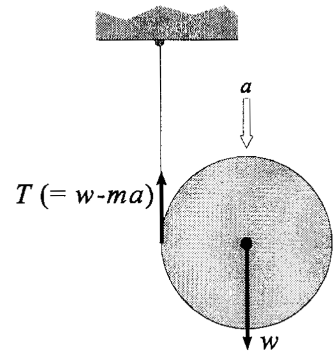
RN-1



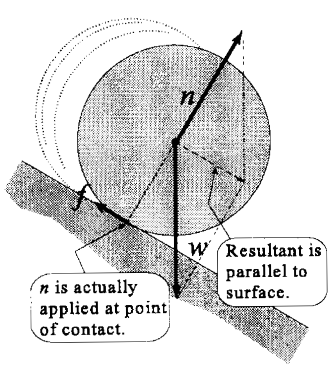
RN-2



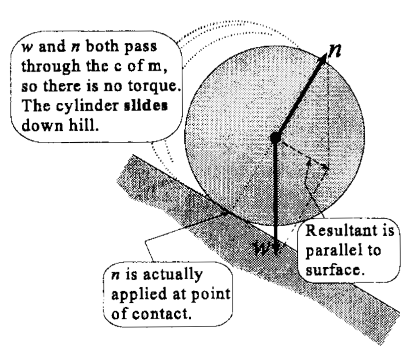
RN-3



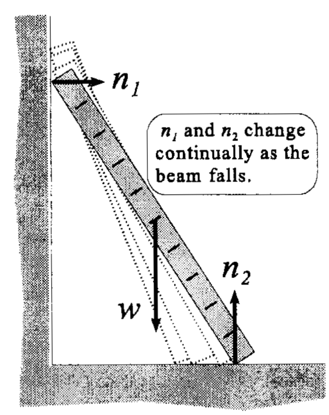
RN-4



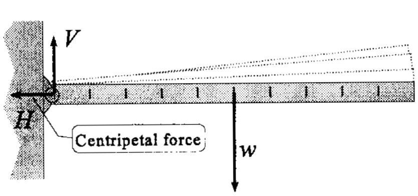
RN-5



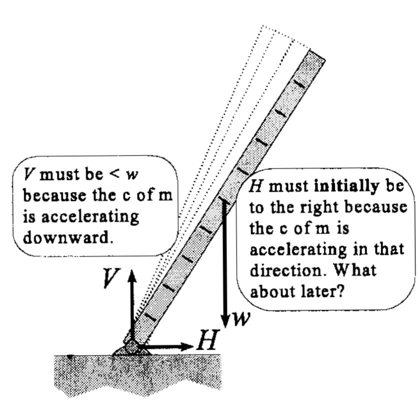
RN-6



RN-7



RN-8



RN-9