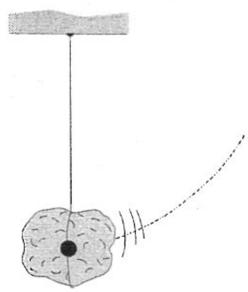
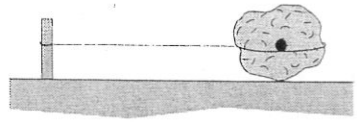
Free-Body Exercises: Circular Motion

Draw free-body diagrams showing forces acting on the rock, and in each case, indicate the centripetal force. Please note that the rock is **not** in equilibrium if it is moving in a circle. The centripetal force depends on angular velocity and there may not be any indication of exactly how big that force should be drawn. Symbols: w = weight, T = tension, f = friction, n = normal reaction force, F_c = centripetal force.

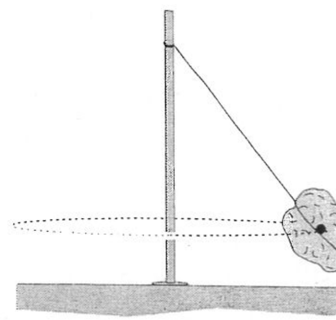
CM-1. Swinging on a rope, at lowest position. No friction.



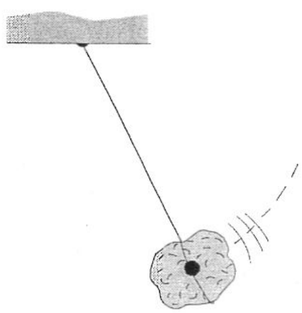
CM-2. Tied to a post and moving in a circle at constant speed on a frictionless horizontal surface. Moving straight out of the paper.



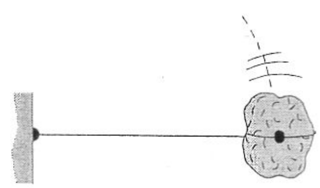
CM-3. String is tied to a post. Rock is moving toward you in a horizontal circle at constant speed. No friction.



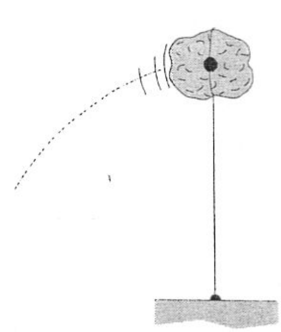
CM-4. Rock is swinging on a rope. No friction.



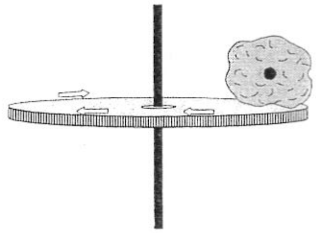
CM-5. Rock is moving downward in a vertical circle with the string horizontal.



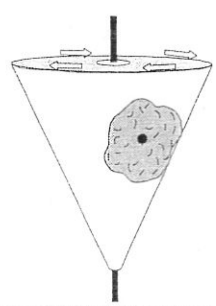
CM-6. Rock is swinging on a rope, at the top of a vertical circle. No friction.



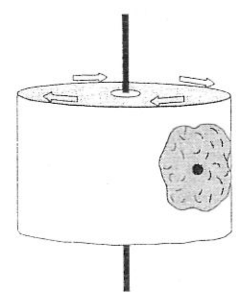
CM-7. Rock is riding on a horizontal disk that is rotating at constant speed about its vertical axis. Friction prevents rock from sliding. Rock is moving straight out of the paper.



CM-8. Rock is resting against the **frictionless** inside wall of a cone. It moves with the cone, which rotates about its vertical axis at constant angular speed.



CM-9. Rock is stuck by friction against the inside wall of a drum rotating about its vertical axis at constant speed. Rock is moving straight out of the paper.



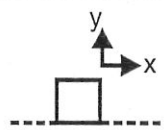
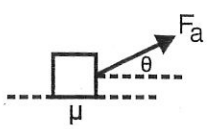
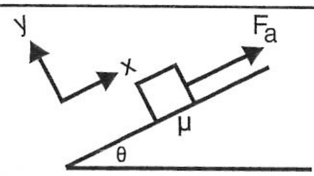
fications found to improve their effectiveness.

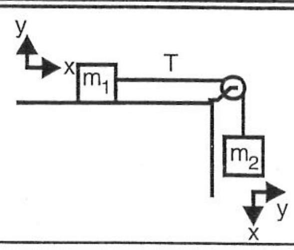
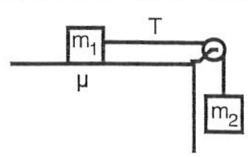
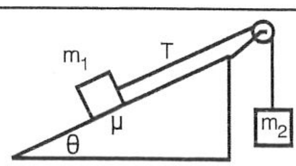
References

1. James E. Court, *Phys. Teach.*, **31**, 104 (1993).
2. Conference on the Introductory Physics Course (May 1993). The proceedings of this landmark conference have been published by John Wiley & Sons, under the auspices of Rensselaer Polytechnic Institute and the National Science Foundation (edited by Jack Wilson, ISBN 0-471-15557-8).
3. Richard R. Hake, private communication; See also *Phys. Teach.* **30**, 546 (1992).

Graded Exercises in Drawing and Utilizing Free-Body Diagrams

Using a ruler, draw free-body diagrams (FBD's) showing all forces acting on each body. Coordinate directions are indicated in the leading diagram of a sequence. Forces that are replaced by their x- and y- components should be shown canceled out. Then using each FBD as a guide, write down the ΣF_x and ΣF_y expressions, carrying them to the point where numerical values might be substituted for F_a, m, θ, ϕ, and μ.

I. ONE-BODY CONFIGURATIONS	F-B Diagram (Show only x- and y-components of all forces acting ON the body)	ΣF_x =	ΣF_y =
1. Frictionless level surface.			
2. Level surface with friction. Applied force at an angle θ.			
3. Incline with friction. Applied force parallel to incline. $F_a > W_{//}$			

II. TWO-BODY CONFIGURATIONS (Assume ideal pulleys)	Take the x-axis to lie along the direction of motion of each body. See #4 for the example.	ΣF_x =	ΣF_y =
4. m_1 is on a frictionless horizontal surface and is connected to hanging mass m_2 by a massless string.		m_1: m_2	m_1: m_2:
5. Same as #4 except that m_1 experiences friction.		m_1: m_1:	m_1: m_2:
6. m_1 experiences friction. $m_1 \sin\theta > m_2$		m_1: m_2:	m_1: m_2: