Lecture 19:
Problem Solving Review
For test 2

Concepts Work and Energy

- Definition and sign of work
- Force perpendicular to path does zero work
- Conservative force: work independent of path
- Force component as negative derivative of potential energy
- Potential energy diagrams
- Energy problems

Concepts Universal Gravitation

- Free fall acceleration
- Satellite motion
- Escape speed
- Space travel

Concepts Momentum and Impulse

- Impulse = change in momentum vector
- Inelastic, perfectly inelastic, elastic collisions
- Center of mass motion under external forces
- Problems for momentum conservation in collisions and explosions

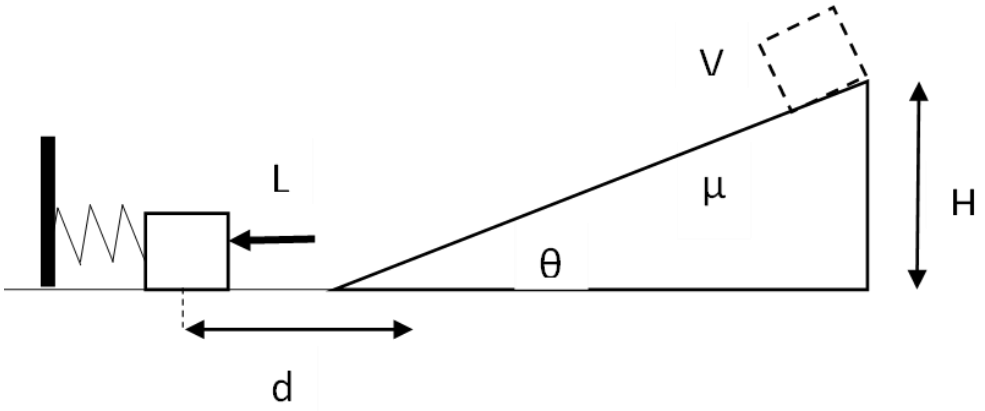
Concepts Static Fluids

- Pressure increase with depth
- Pascal's principle
- Buoyancy

Example 1

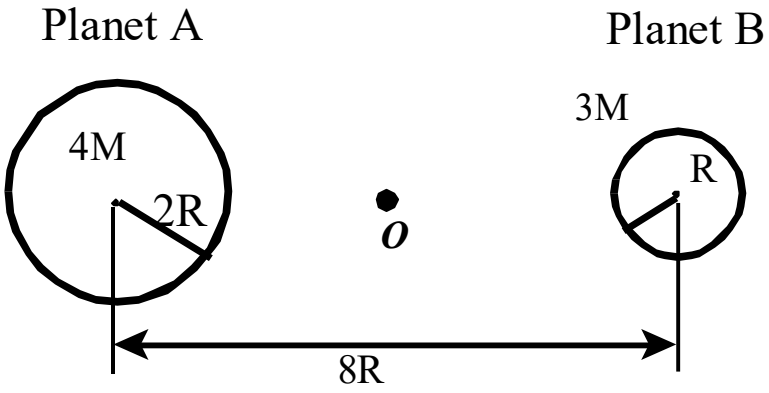
A block of mass *M* is pushed against a spring with unknown spring constant, compressing it a distance *L*. When the block is released from rest, it travels a distance *d* on a frictionless horizontal surface and then up a **rough** incline that has a coefficient of kinetic friction μ with the box. The incline makes an angle θ above the horizontal. When the block reaches height *H* on the incline, its speed is *V*.

Derive an expression for the force constant *k* of the spring in terms of system parameters.



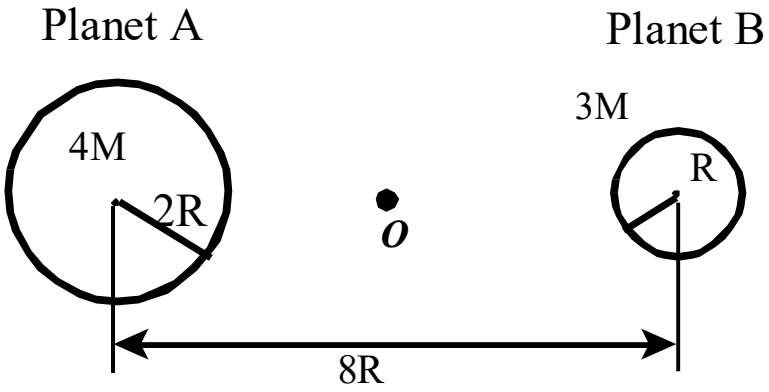
Example 2

Planet A has mass 4*M* and radius 2*R*. Planet B has mass 3*M* and radius *R*. They are separated by center-to-center distance 8*R*. A rock of mass m is placed halfway between their centers at point ***O*** and released from rest. (Ignore any motion of the planets**.)**



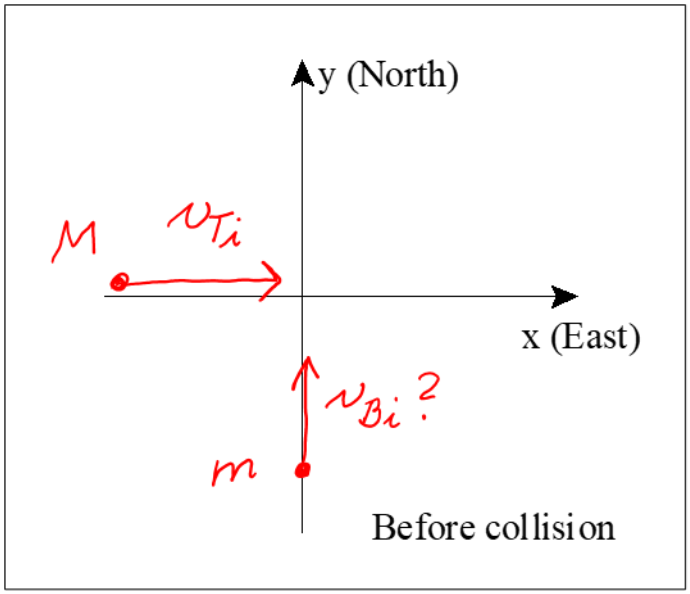
Derive an expression for the **magnitude and direction** of the acceleration of the rock at the moment it is released.

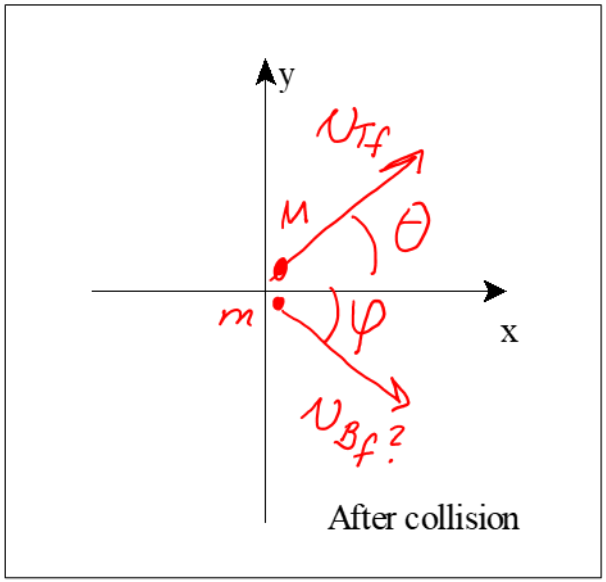
Derive an expression, in terms of relevant system parameters, for the speed with which the rock crashes into a planet.



Example 3

Bilbo and Thorin slide on a frozen pond. The pond surface is frictionless and horizontal. Thorin with mass *M* is originally moving **eastwards** with speed v_{Ti}. Bilbo with mass *m* is originally sliding **northward**. They collide and after the collision Thorin is moving with speed v_{Tf} at angle θ north of east (i.e. above the positive x-axis), while Bilbo is moving at angle φ south of east (i.e. below the positive x-axis). Derive expressions for the speed of Bilbo before and after the collision, in terms of system parameters.





Derive an expression for the **average force** exerted **on** Thorin **by** Bilbo in unit vector notation, if the two are in contact for a time span Δt.