Lecture 19:
Problem Solving Review
For test 2

How to identify type of problem?

- If the problem mentions planets, moons, stars, spaceships, meteorites... Universal gravitation (U, F)
- If the problem is a collision or explosion:

  Linear momentum is conserved

  Mechanical energy changes

  Only if the collision is elastic:

  Linear momentum and mechanical energy are both conserved
- If external forces dominate, such as spring, gravity, friction: Energy/Work

Caution: some problems may require several tools!

Tips for multiple choice

- Take enough time. The multiple choice page is worth as many points as each of the other pages.
- Identify the concept that is tested by the question.
- Recall what you know about this concept.
- If possible, try to answer the question as if it were open-ended, without looking at the answer options
- Sketching a diagram or working out a few lines of equations may be necessary.

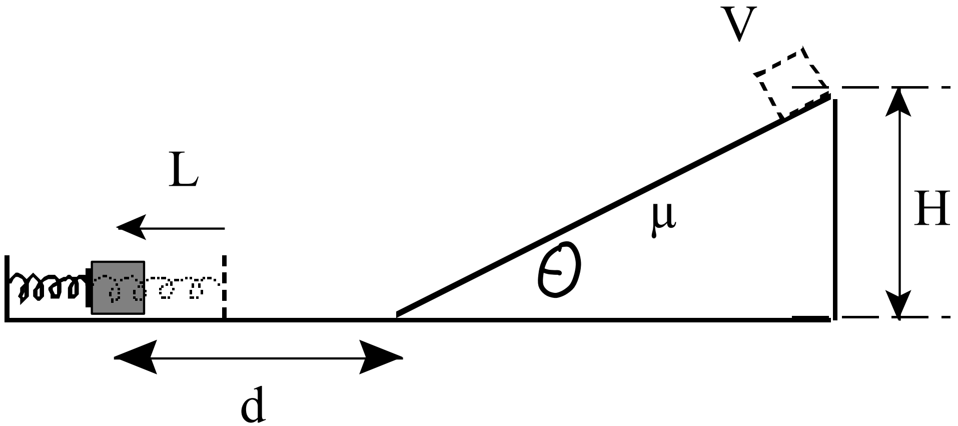
Concepts

- Force perpendicular to path does zero work
- Conservative force: work independent of path
- Force component as negative derivative of potential energy
- Potential energy diagrams
- Free fall acceleration from universal gravitation
- Satellite motion
- Escape speed
- Impulse = change in momentum vector
- Inelastic, perfectly inelastic, elastic collisions
- Center of mass motion under external forces

Example 1

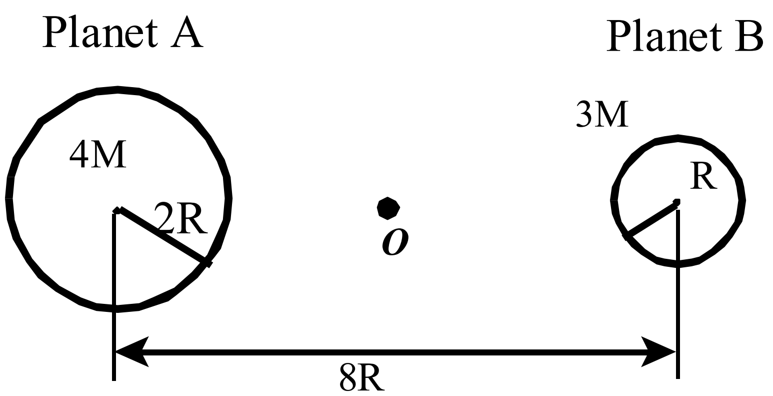
A block of mass *M* is pushed against a spring with unknown spring constant, compressing it a distance *L*. When the block is released from rest, it travels a distance *d* on a frictionless horizontal surface and then up a **rough** incline that has a coefficient of kinetic friction μ with the box. The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



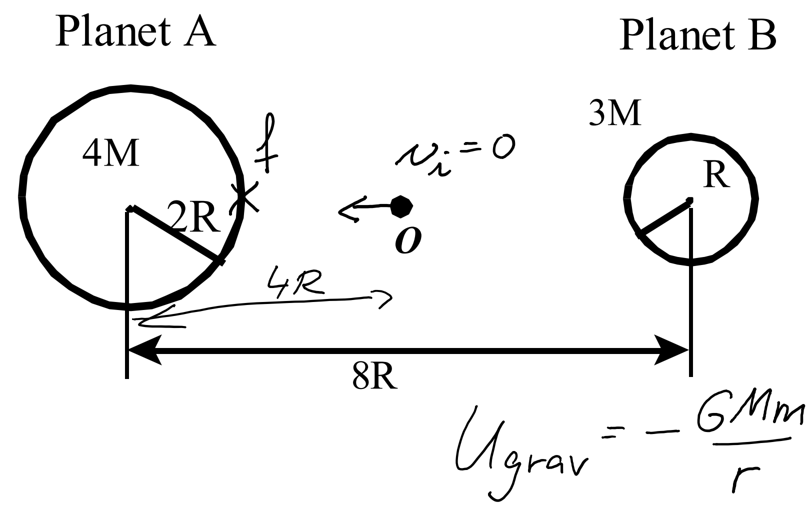
Example 2

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.)



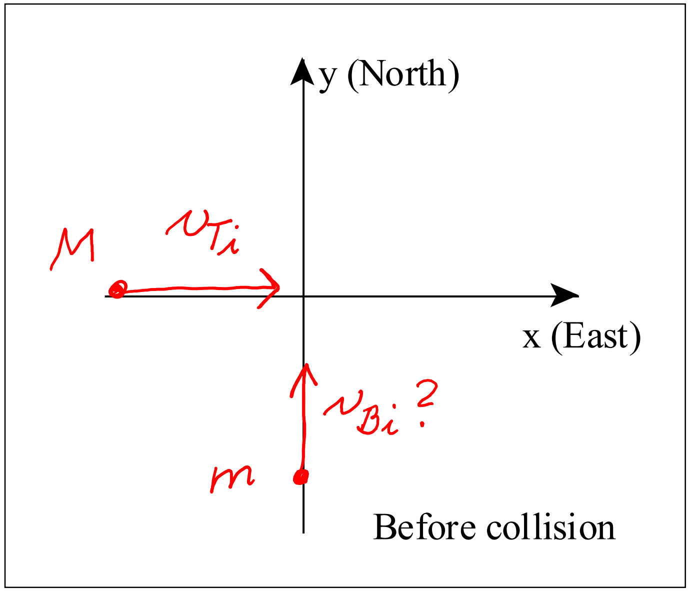
Derive an expression for the **magnitude and direction** of the acceleration of the rock at the moment it is released.

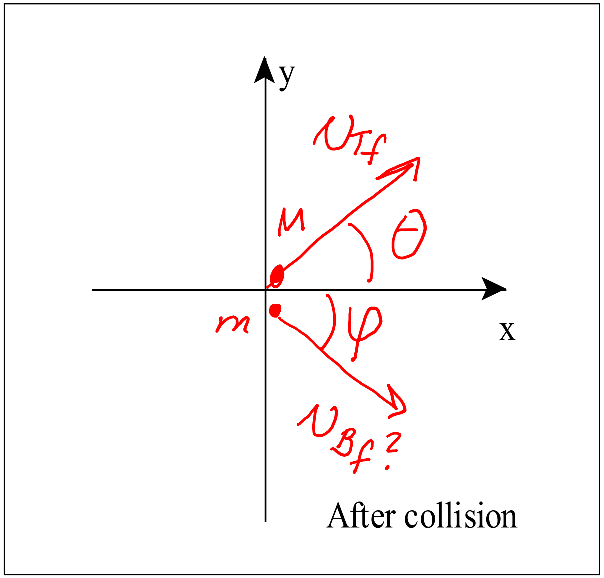
Derive an expression, in terms of relevant system parameters, for the speed with which the rock crashes into a planet.



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 $\boldsymbol{v_{Ti}}$. Bilbo with mass *m* is originally sliding **northward**. They collide and after the collision Thorin is moving with speed $\boldsymbol{v_{Tf}}$ 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.