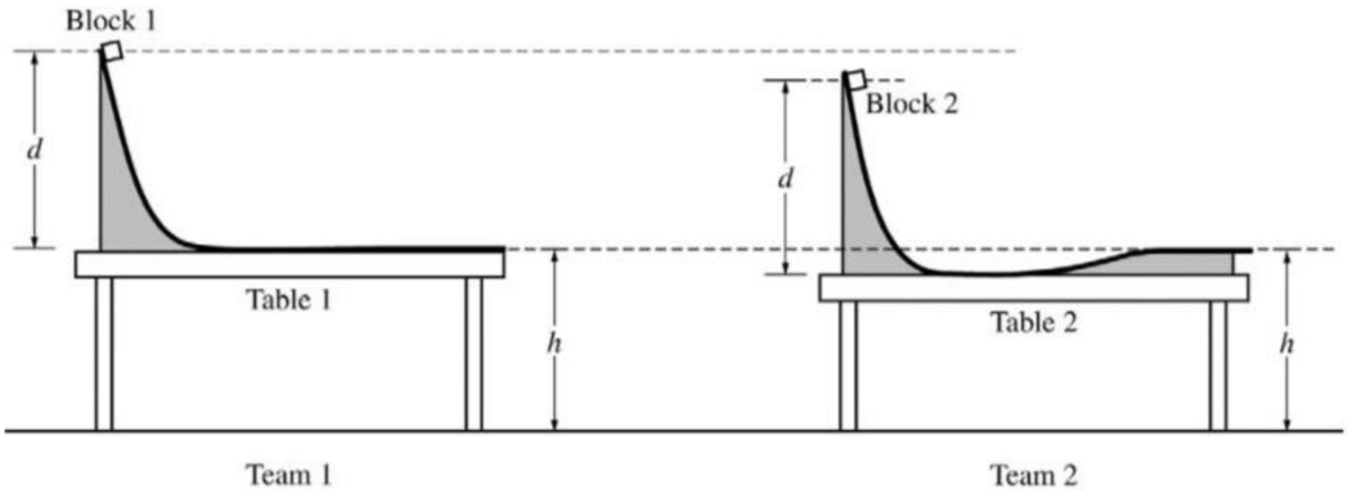
AP physics – Unit 4 FRQ – Short answer



(7 points, suggested time 13 minutes)

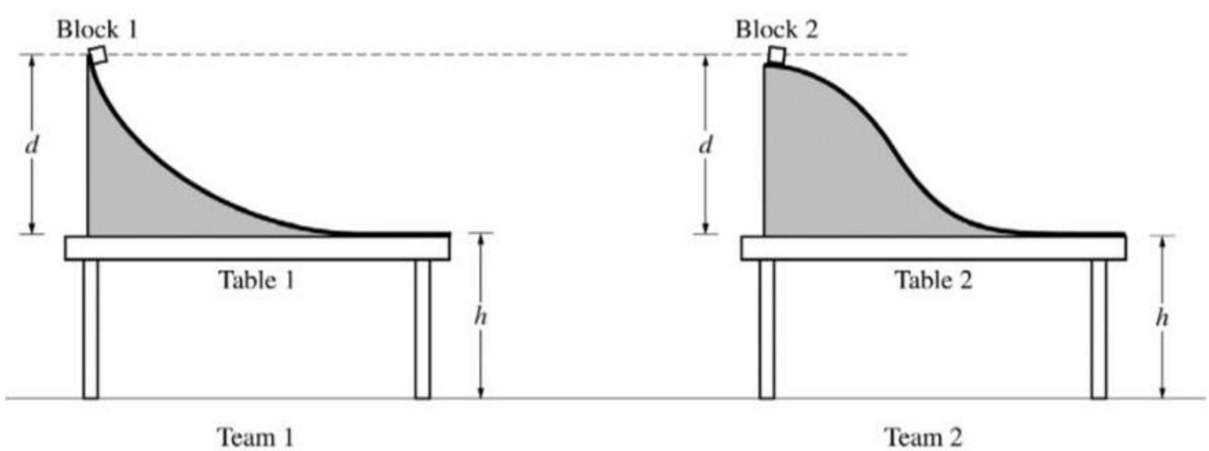
A physics class is asked to design a low-friction slide that will launch a block horizontally from the top of a lab table. Teams 1 and 2 assemble the slides shown above and use identical blocks 1 and 2, respectively. Both slides start at the same height d above the tabletop. However, team 2's table is lower than team 1's table. To compensate for the lower table, team 2 constructs the right end of the slide to rise above the tabletop so that the block leaves the slide horizontally at the same height h above the floor as does team 1's block (see figure above).

(a) Both blocks are released from rest at the top of their respective slides. Do block 1 and block 2 land the same distance from their respective tables?

____ Yes ____ No

Justify your answer.

In another experiment, teams 1 and 2 use tables and low-friction slides with the same height. However, the two slides have different shapes, as shown below.



(b) Both blocks are released from rest at the top of their respective slides at the same time.

i. Which block, if either, lands farther from its respective table?

____ Block 1 ____ Block 2 ____ The two blocks land the same distance from their respective tables.

Briefly explain your reasoning without manipulating equations.

ii. Which block, if either, hits the floor first?

____ Block 1 ____ Block 2 ____ The two blocks hit the floor at the same time.

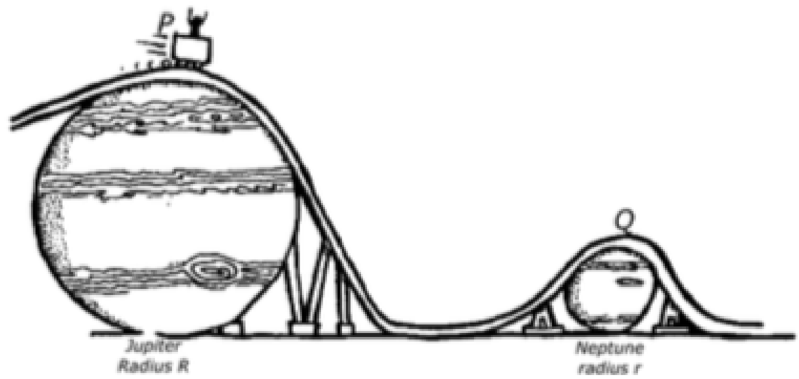
Briefly explain your reasoning without manipulating equations.

Question 2

i

Scenario

Engineers A, B, and C are responsible for creating a new roller-coaster ride. Engineer A comes up with the idea sketched to the right, which is a solar-system themed coaster. The track starts at point P on top of a sphere (radius R) representing Jupiter, then goes down to ground level, then goes over a sphere (radius r) representing Neptune (the top of which is point Q), and then back to the ground again, etc. The spheres are intended to be built to the actual scale of the planets they represent. The coaster consists of a single cart of mass m that experiences no friction or other dissipative forces. The coaster starts from rest at point P.



The other two engineers are extremely concerned about the safety of this coaster. If the normal force becomes any number less than zero, the cart loses contact with the track and becomes a projectile, severely injuring the occupants. The engineers reason this way:

Engineer B: "If the height difference between the top of Jupiter and the top of Neptune is too much, the cart will go too fast at point Q, causing the cart to lose contact with the track."

Engineer C: "No, it's not the difference between heights that is the problem, but the small radius of curvature of the track as it goes over Neptune."

Quantitative Analysis

A: Write expressions for the following.

i. The speed of the cart when it is on the top of the Neptune sphere

a) Explain how Engineer B is correct in terms of Energy
b) Explain how Engineer C is correct in terms of forces and circular motion
c) Derive an expression for the speed of the coaster at point Q in terms of R, r, and fundamental constants.
d) What is the smallest radius of Neptune, in terms of R, that will allow the coaster to stay in contact with the track at point Q.