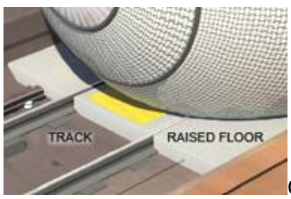
NEWTON'S 2ND LAW & Some Fluids & FRICTION

Unit 6 & 7 Dr. John P. Cise, Professor of Physics, Austin Community College, 1212 Rio Grande St., Austin Tx .78701 jpcise@austincc.edu & NYTimes Nov. 20,2012 by Henry Fountain

Holding Back Floodwaters With a Balloon

A look at an inflatable 32 ft long,16 ft diameter device that could save tunnels from flooding.

Multimedia



Graphic

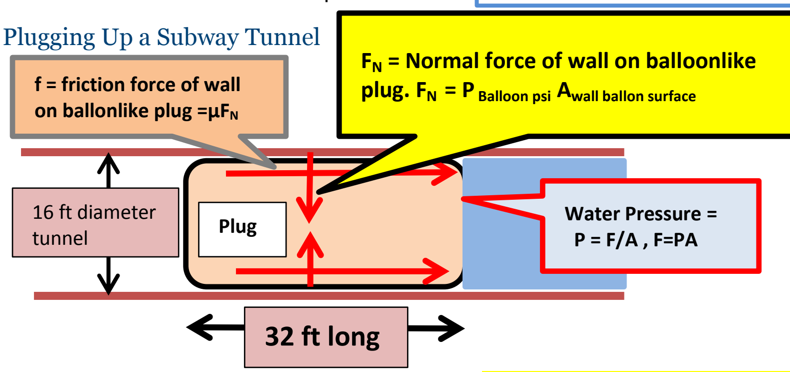
INTRODUCTION: Click on the Multimedia graphic first and review it. The depth below sea level (on average) these balloonlike plugs would be placed is about 40 ft. Important data about the balloon and tunnel is located in graphic at lower left.

QUESTIONS: (a) Find water pressure(lb./ft^2) on plug's 16 ft diameter surface(A)? **(b)** Find area(A in ft^2) of balloon's 16 ft diameter surface? **(c)** Find the force(F in lb.) due to water pressure on the 16 ft diameter balloonlike plug surface? **Note: The friction force(f) of wall on balloonlike plug must be equal to this force(of water) to hold back the sea water.** **(d)** Find the surface area of 32 ft long, 16 ft diameter plug which will touch the tunnel wall? **(e)** It is stated the balloon plug will have 10-20 psi when inflated. Using 15 psi as an average, find 15 psi in lb./ft^2 ? **(f)** Find F_N normal force of tunnel wall on plug? Note: $F_N = P_{balloon\ psi}\ A_{balloon\ area\ touching\ wall}$ **(g)** Find "minimum" coefficient of friction(μ) required between tunnel wall and balloonlike plug surface to hold back the 40 ft of water pressure? Note: $f = \mu F_N$

MORE HINTS: $D_{water} = 62.4$ lb./ft^3 , $P_{water} = Dh_{depth}$, $A_{circle} = \pi R^2$, $F = P A$, 144 in^2 = 1 ft^2

ANSWERS: (a) P_{water} = 2496 lb./ft^2 , (b) $A_{surface\ circle}$ = 201.1 ft^2 , (c) F(~f) = 501,846 lb. (d) $A_{wall\ balloon\ surface}$ = 1608 ft^2 , (e) $P_{balloon\ psi}$ = 2160 lb./ft^2 , (f) F_N = 3,474,350 lb. (g) $\mu = f/F_N$ = or > 0.144

Plugging Up a Subway Tunnel



As air flowed into it through a hose, the **bundle inflated until it was crammed tight inside the 16-foot-diameter tunnel, looking like the filling in a giant concrete-and-steel cannoli.** "The **goal is to provide flooding protection for transportation tunnels**," The idea is a simple one: rather than retrofitting tunnels with metal floodgates or other expensive structures, the **project aims to use a relatively cheap inflatable plug to hold back floodwaters.** In theory, it would be like blowing up a balloon inside a tube. But in practice, developing a plug that is strong, durable, quick to install and foolproof to deploy is a difficult engineering task, one made even more challenging because of the pliable, relatively lightweight materials required. **"Water is heavy,there's a lot of pressure,"** said Greg Holter, an engineer with Pacific Northwest National Laboratory who helps manage the project. In all, seven of the city's 14 under-river subway tunnels were flooded during the storm, as were several major highway tunnels.

Dr. Barbero realized that **the forces exerted on the pressurized plug, and the ((need to rely on friction against the tunnel walls)) to keep it in place under the onslaught of floodwaters**, meant that it had to be made from very tough materials. Experts from ILC Dover, a company in Delaware that makes high-strength soft structures like spacesuits and the force-absorbing air bags used for some of the Mars rover landings, suggested fabric **made from Vectran**, a strong but lightweight yarn spun from a liquid-crystal polymer.

Most of the obstructions can be dealt with by modifying a short section of the tunnel to accommodate the **plug, which is 32 feet long when inflated**.