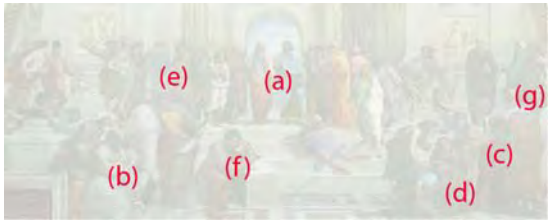
The Laws *of* **Motion**

Aristotle
384-322 BC

"School of Athens", Raphael, Vatican

Pictured:
(a) Plato (as L. da Vinci) & Aristotle
(b) Pythagorus (with book)
(c) Ptolemy (holding earthly sphere, facinc Zoroaster w. heavenly sphere)
(d) Euclid (with compass)
(e) Alexander (blue toga) & Socrates (green)
(f) Heraclitus (as Michelangelo)
(g) Raphael (facing viewer)



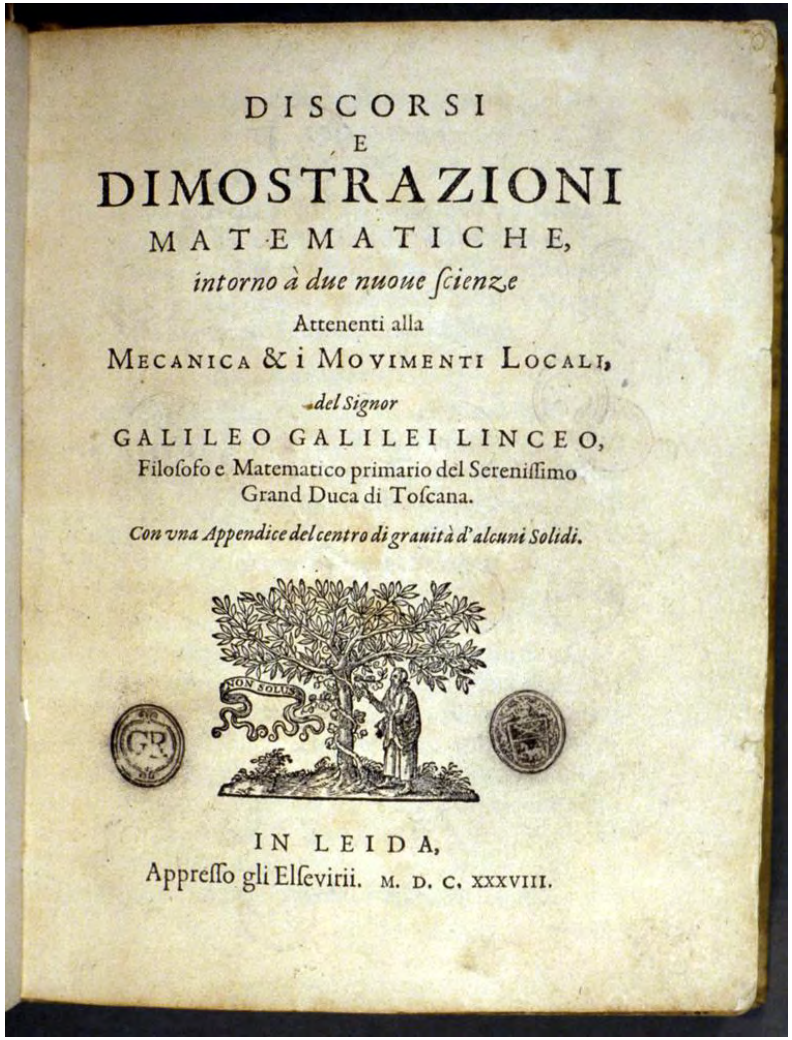
http://un2sg4.unige.ch/athena/raphael/raf_ath4.html

From what we have said, then, it is clear that the weight of the infinite body cannot be finite. It must then be infinite. We have therefore only to show this to be impossible in order to prove an infinite body impossible. But the impossibility of infinite weight can be shown in the following way. **A given weight moves a given distance in a given time; a weight which is as great and more moves the same distance in a less time, the times being in inverse proportion to the weights.** **For instance, if one weight is twice another, it will take half as long over a given movement.** Further, a finite weight traverses any finite distance in a finite time. It necessarily follows from this that infinite weight, if there is such a thing, being, on the one hand, as great and more than as great as the finite, will move accordingly, but being, on the other hand, compelled to move in a time inversely proportionate to its greatness, cannot move at all. The time should be less in proportion as the weight is greater. But there is no proportion between the infinite and the finite: proportion can only hold between a less and a greater finite time. And though you may say that …

Aristotle "On the Heavens" 350 B.C.

Galileo
1564-1642

Giuseppe Bezzuoli, *Galileo esegue l'esperimento della caduta dei gravi*
Museo Zoologico "La Specola“, Florence



DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue ſcienze
Attenenti alla
MECANICA & i MOVIMENTI LOCALI,
del Signor
GALILEO GALILEI LINCEO,
Filoſofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.
Con vna Appendice del centro di grauità d'alcuni Solidi.

IN LEIDA,
Appreſſo gli Elſevirii. M. D. C. XXXVIII.

Galileo's "Two New Sciences" 1638

When, therefore, I observe a stone initially at rest falling from an elevated position and continually acquiring new increments of speed, why should I not believe that such increases take place in a manner which is exceedingly simple and rather obvious to everybody? If now we examine the matter carefully we find no addition or increment more simple than that which repeats itself always in the same manner. This we readily understand when we consider the intimate relationship between time and motion; for just as uniformity of motion is defined by and conceived through equal times and equal spaces (thus we call a motion uniform when equal distances are traversed during equal time-intervals), so also we may, in a similar manner, through equal time-intervals, conceive additions of speed as taking place without complication; thus we may picture to our mind a motion as uniformly and continuously accelerated when, during any equal intervals of time whatever, equal increments of speed are given to it. Thus if any equal intervals of time whatever have elapsed, counting from the time at which the moving body left its position of rest and began to descend, the amount of speed acquired during the first two time-intervals will be double that acquired during the first time-interval alone; so the amount added during three of these time-intervals will be treble; and that in four, quadruple that of the first time interval. To put the matter more clearly, if a body were to continue its motion with the same speed which it had acquired during the first time-interval and were to retain this same uniform speed, then its motion would be twice as slow as that which it would have if its velocity had been acquired during two time intervals.

And thus, it seems, we shall not be far wrong if we put the increment of speed as proportional to the increment of time; hence the definition of motion which we are about to discuss may be stated as follows: **A motion is said to be uniformly accelerated, when starting from rest, it acquires, during equal time-intervals, equal increments of speed**

Isaac Newton
1642-1727


ONE POUND
£1
Sir Isaac Newton
1642 · 1727


ISAAC NEWTON
1643-1727
Δ(mv)=FΔt
DEUTSCHE
BUNDESPOST
100
1993

PHILOSOPHIÆ NATURALIS PRINCIPIA MATHEMATICA.

Autore *J. S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,

Jussu *Societatis Regiæ* ac Typis *Josephi Streater*. Prostat apud plures Bibliopolas. *Anno* MDCLXXXVII.

AXIOMATA SIVE LEGES MOTUS

Lex. I.

Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum illum mutare.

PRojectilia perseverant in motibus suis nisi quatenus a resistentia aeris retardantur & vi gravitatis impelluntur deorsum. Trochus, cujus partes cohærendo perpetuo retrahunt sese a motibus rectilineis, non cessat rotari nisi quatenus ab aere retardatur. Majora autem Planetarum & Cometarum corpora motus suos & progressivos & circulares in spatiis minus resistentibus factos conservant diutius.

Lex. II.

Mutationem motus proportionalem esse vi motrici impressæ, & fieri secundum lineam rectam qua vis illa imprimitur.

Si vis aliqua motum quemvis generet, dupla duplum, tripla triplum generabit, sive simul & semel, sive gradatim & successive impressa fuerit. Et hic motus quoniam in eandem semper plagam cum vi generatrice determinatur, si corpus antea movebatur, motui ejus vel conspiranti additur, vel contrario subducitur, vel obliquo oblique adjicitur, & cum eo secundum utriusq; determinationem componitur.

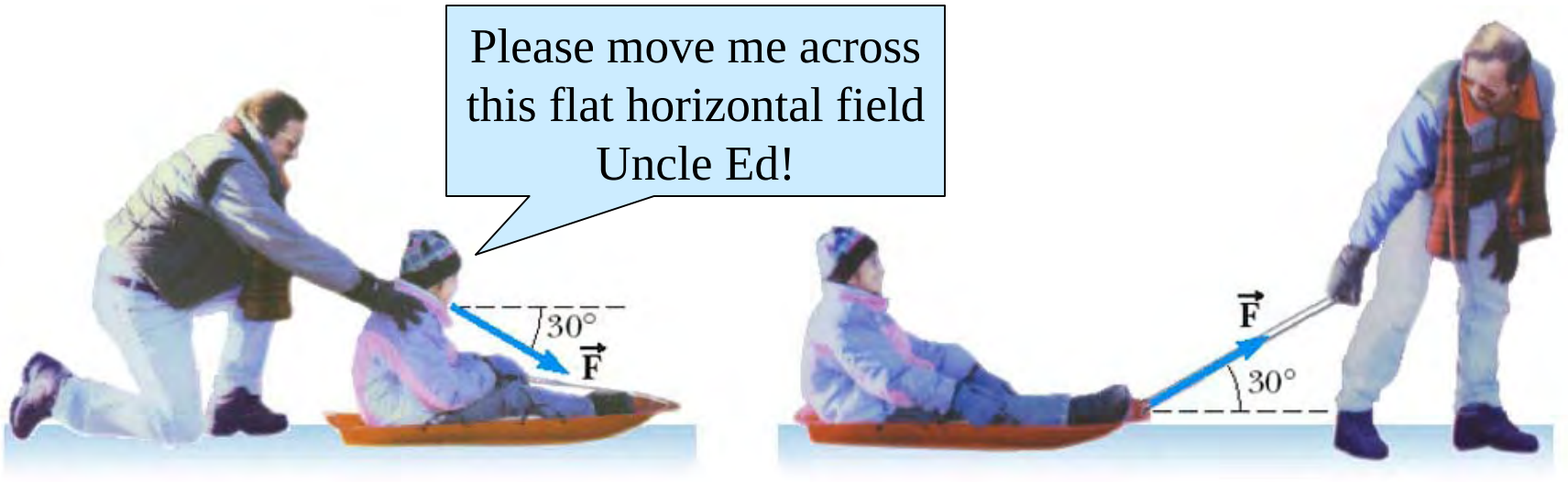
Lex. III.

TABLE 4.2

Coefficients of Friction[a]

	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete	1.0	0.8
Wood on wood	0.25–0.5	0.2
Glass on glass	0.94	0.4
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	—	0.04
Metal on metal (lubricated)	0.15	0.06
Ice on ice	0.1	0.03
Teflon on Teflon	0.04	0.04
Synovial joints in humans	0.01	0.003

[a]All values are approximate.

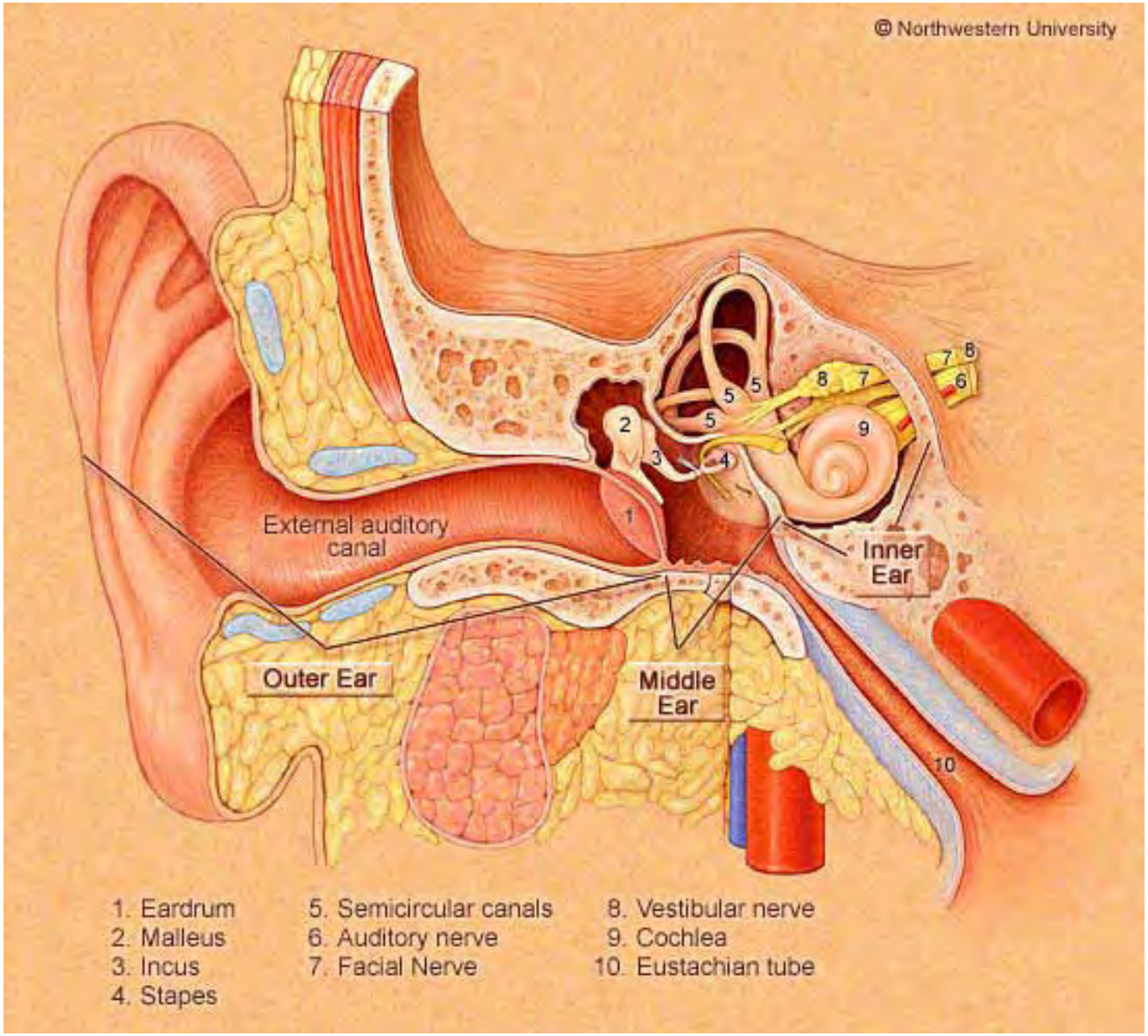


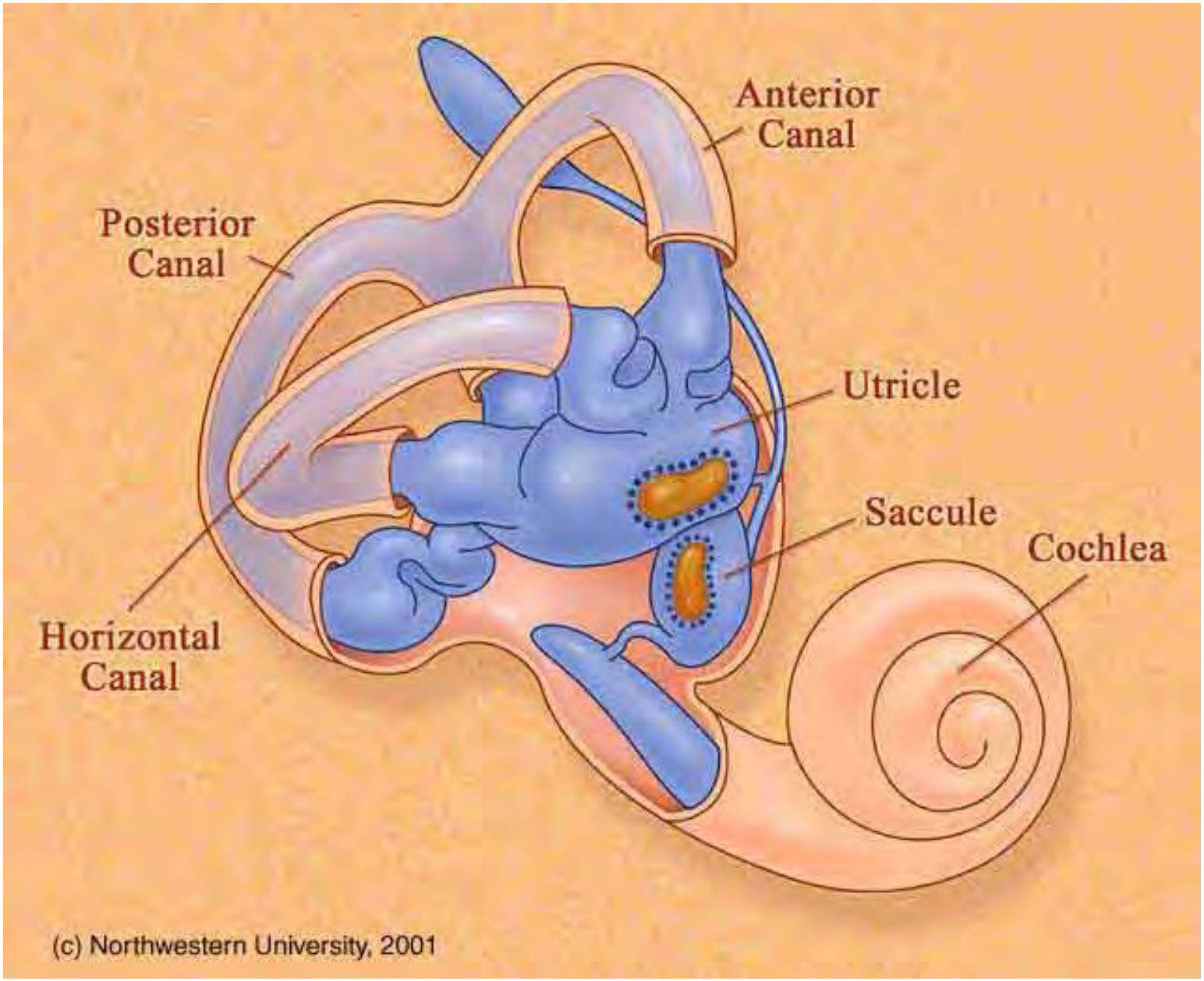
Suppose you're playing with your niece in the snow. She's sitting on a sled and asks you to move her across a flat, horizontal field. You have a choice of:

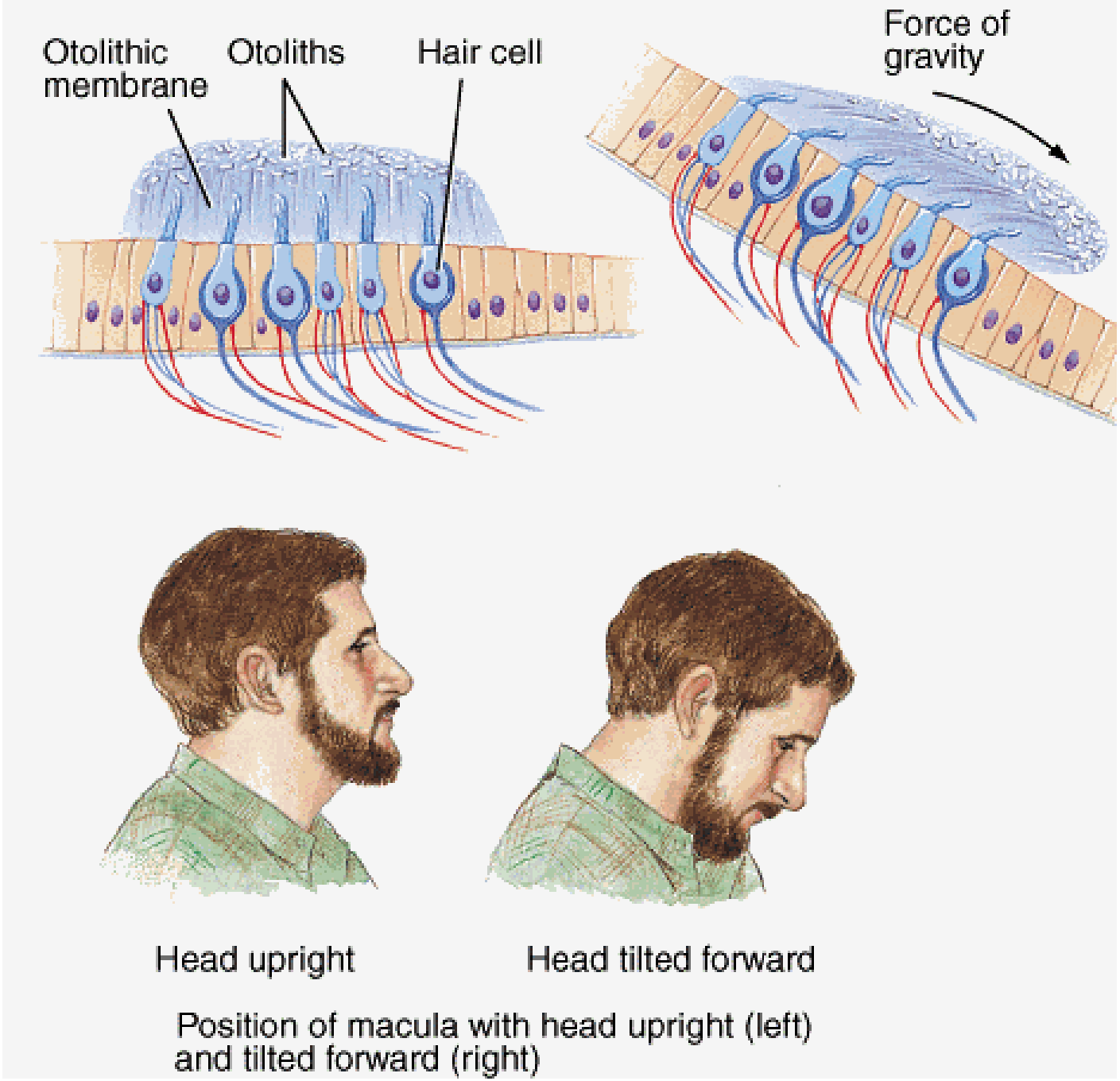
(a) pushing her from behind by applying a force downward on her shoulders at 30° below the horizontal

(b) attaching a rope to the front of the sled and pulling with a force at 30° above the horizontal.

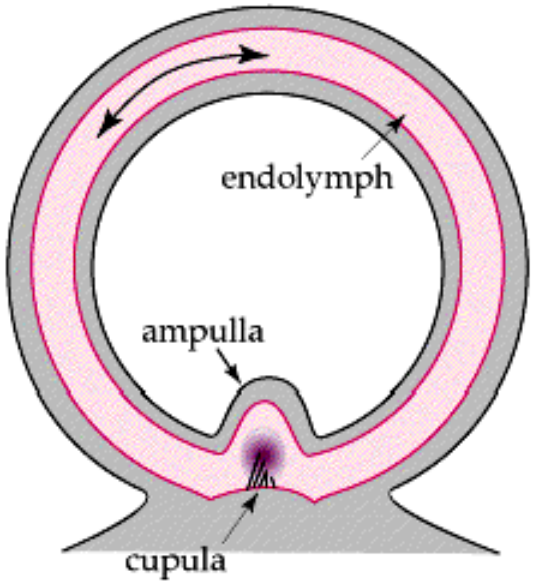
Which option would be easier and why?

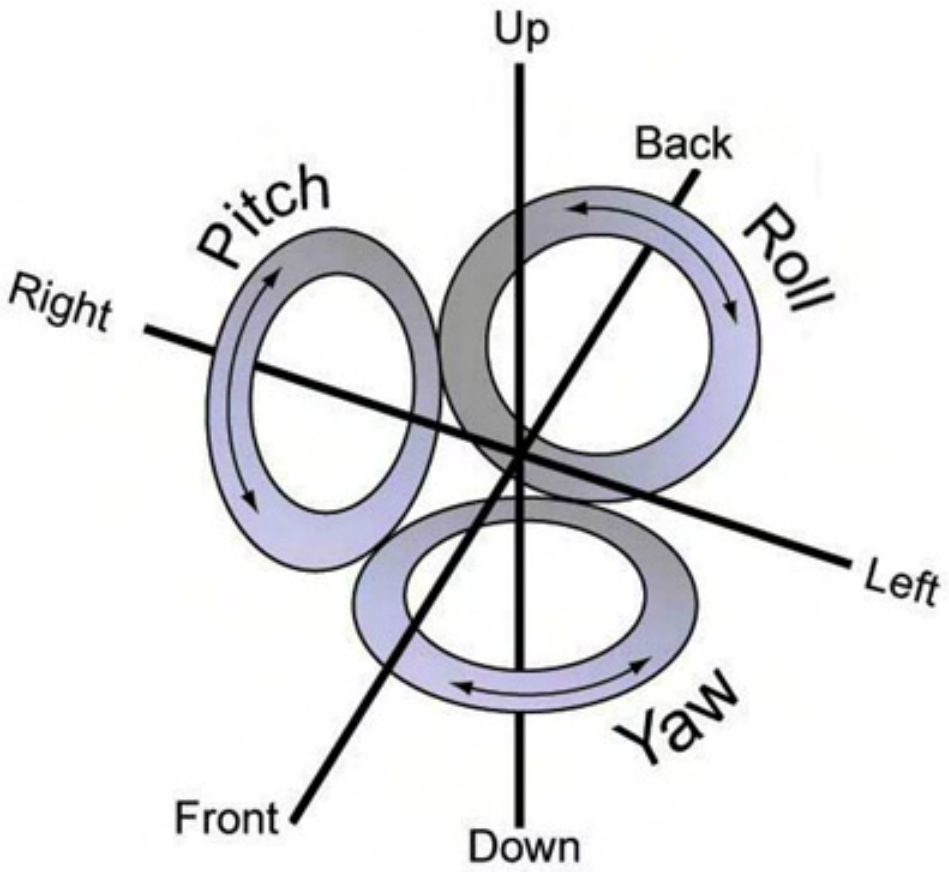

© Northwestern University
External auditory canal
Inner Ear
Outer Ear
Middle Ear
1. Eardrum
2. Malleus
3. Incus
4. Stapes
5. Semicircular canals
6. Auditory nerve
7. Facial Nerve
8. Vestibular nerve
9. Cochlea
10. Eustachian tube

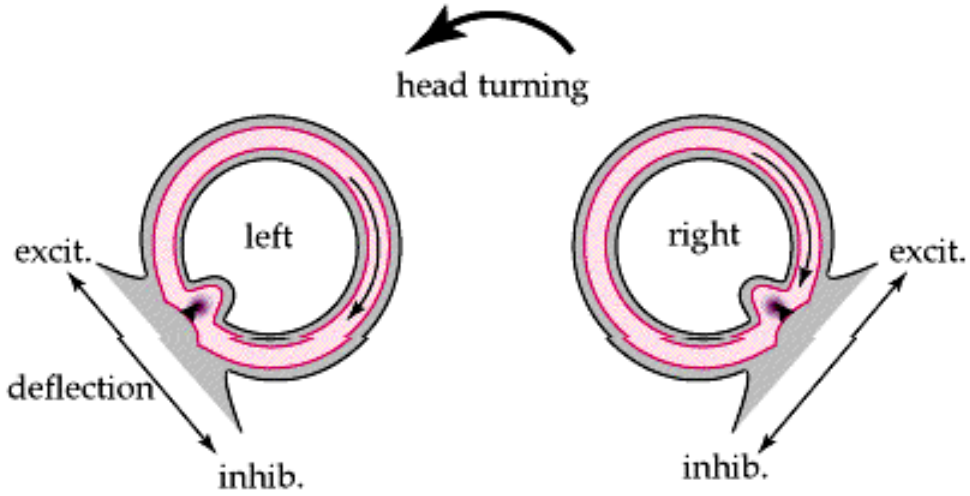

Anterior
Canal
Posterior
Canal
Utricle
Saccule
Cochlea
Horizontal
Canal
(c) Northwestern University, 2001

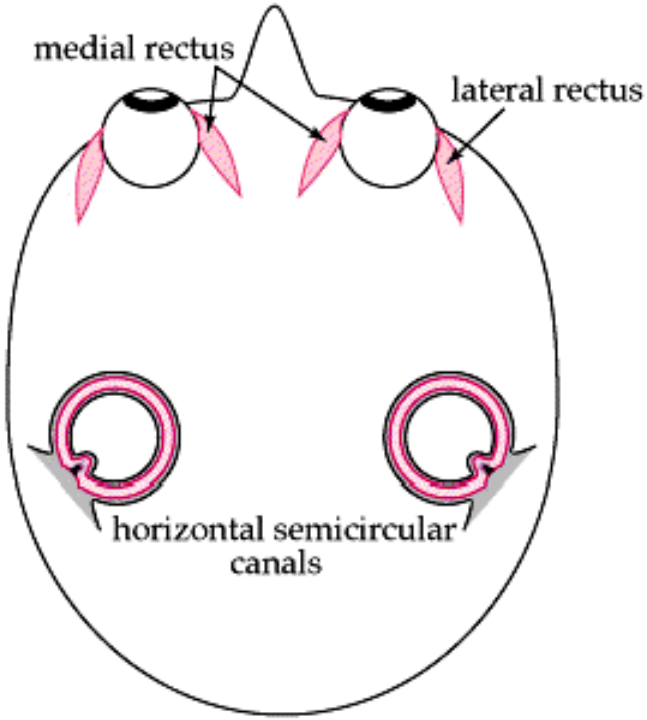


Position of macula with head upright (left) and tilted forward (right)


endolymph
ampulla
cupula


Up
Back
Pitch
Roll
Right
Left
Yaw
Front
Down





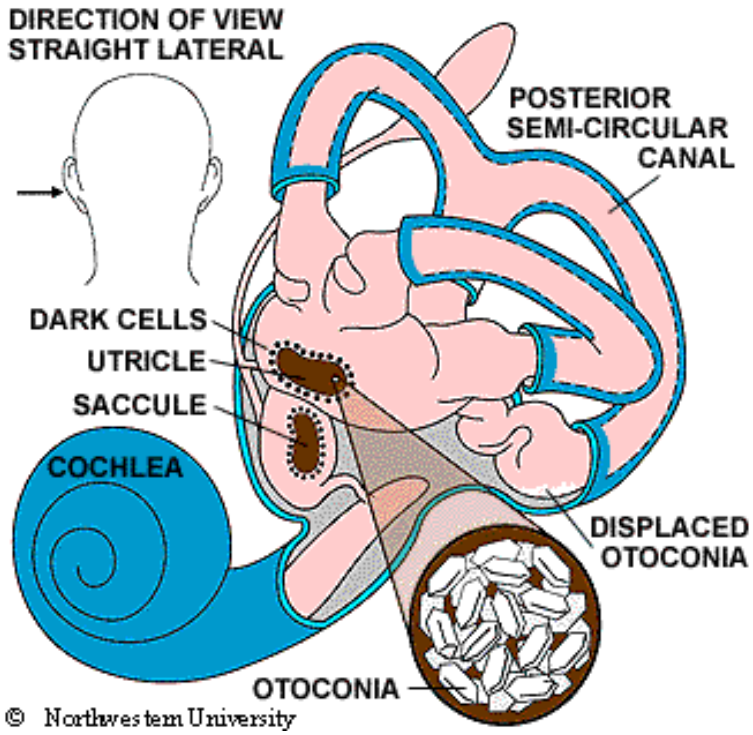
Some sources:

http://thalamus.wustl.edu/course/audvest.html
http://weboflife.nasa.gov/learningResources/vestibularbrief.htm
http://www.dizziness-and-balance.com/disorders/bppv/bppv.html

Benign positional vertigo: recognition and treatment

Thomas Lempert, Michael A Gresty, Adolfo M Bronstein

The clinical features of benign positional vertigo are consistent with the hypothesis that the posterior canal contains free floating particles that are heavier than the surrounding endolymph.[9–11] After the head is moved in the plane of the canal the material will fall to the undermost portion of the canal, dragging the endolymph in the same direction and leading to deflection of hair cells (fig 3). When the head is moved in the opposite direction the particles will also be shifted in the opposite direction to induce a nystagmus in the reversed direction. The latency of the development of nystagmus may be attributed to the time taken for the particles to be displaced but also to the particles' adherence to the membranous wall of the labyrinth. Adherence may also explain why a brisk head movement is needed to induce the vertigo.



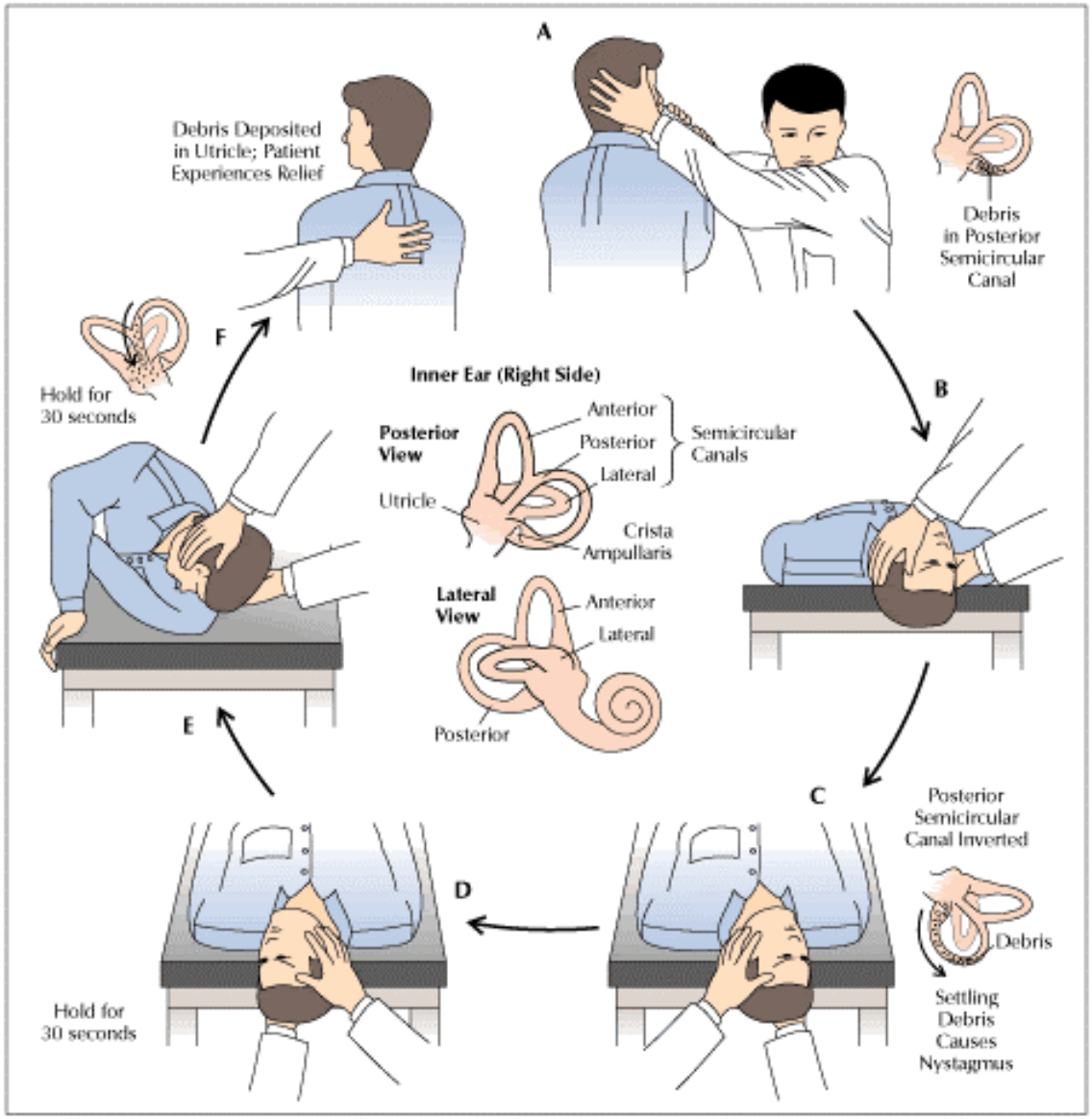


Figure 2. In the modified Epley maneuver, the patient's head is systematically rotated so that the loose particles slide out of the posterior semicircular canal and back into the utricle. The first step in the maneuver is the Dix-Hallpike test. If the vertigo affects the right ear, the patient is brought to the head-hanging position with the right ear turned downward (A-C). The physician then moves to the end of the table and rotates the patient's head to the left, with the right ear turned upward (D). The head is held in that position for 30 seconds. The patient then rolls onto the left side (E). Meanwhile, the examiner rotates the patient's head leftward until the nose points toward the floor. That position is also held for 30 seconds. Finally, the patient is lifted into the sitting position with the head facing left (F).