Chapter 4 (Finish Newton's Laws & Momentum)
Chapter 5: Newtonian Gravity

Outline of today's class (apart from quizzes):

- Momentum & its conservation, closing comments/examples
- Newton's Laws: review & more examples
- Few comments & demos on rotational motion (not in book)
- Newtonian Gravity

"Momentum" = mass × velocity (a vector); $p = mv$

Why relevant?

Because of an extremely important *conservation law*:

If $F_{external}$ (on a "system", i.e. more than 1 object, then p_{total}(of system!) = const.

Examples:

C.E. 60: In terms of momentum, why does a gun recoil?

A: p_{gun} is conserved → bullet's forward p balanced by gun's backward p – until stopped by shoulder.

Playing pool: momentum conservation in 2 dimensions!

Newton's Laws:

1. Bodies have inertia
2. $F_{net} = m \times a$
3. "action = reaction"

Questions? What is least clear or most confusing?

Problem 12: 10^3 kg, 100 N air resistance, 200 N rolling resistance. How large a force from road on drive wheels in order to achieve a = 0.5 m/s^2 ?

A: $F_{net} = ma = 500$ N. Therefore $F_{drive} = 500$ N + 100 N + 200 N = 800 N.

C.E. 52: Three acceleration devices in a car?

Quiz # 25: A 80 kg runner speeds up from 5 m/s to 7 m/s in 4 s. The frictional force by the ground on the runner is

(a) 80 N (b) 800 N (c) 40 N (d) 20 N (e) 320 N

Hint: calculate acceleration first.

Quiz # 26: You press downward with a 100 N force on a book weighing 20 N. The book is and remains at rest on a table. F_{net} on the book and the force (plus its direction) exerted by the table on the book are, respectively,

(a) 20 N & 100 N upward
(b) 120 N & 20 N upward
(c) 100 N & 100 N downward
(d) 0 N & 120 N upward
(e) Both are zero

Quiz # 27: You lift a ball (w = 20 N, m = 2 kg) with a string. The string exerts a 40 N force on the ball. a_{Ball} = ?

(a) 15 m/s^2 (b) 10 m/s^2 (c) 25 m/s^2 (d) 5 m/s^2 (e) zero

Quiz # 28: Consider the famous "frictionless" apple (weight = 2 N) thrown upward in earlier quizzes. On the way up, to the top of its trajectory, its velocity points in the following direction, and the strength and direction of the net force on the apple are

(a) upward, and 2 N downward
(b) upward, and zero
(c) upward, and 2 N upward
(d) downward, and 2 N downward
(e) downward, and zero

Brief excursion into rotational motion (for fun, not in book):

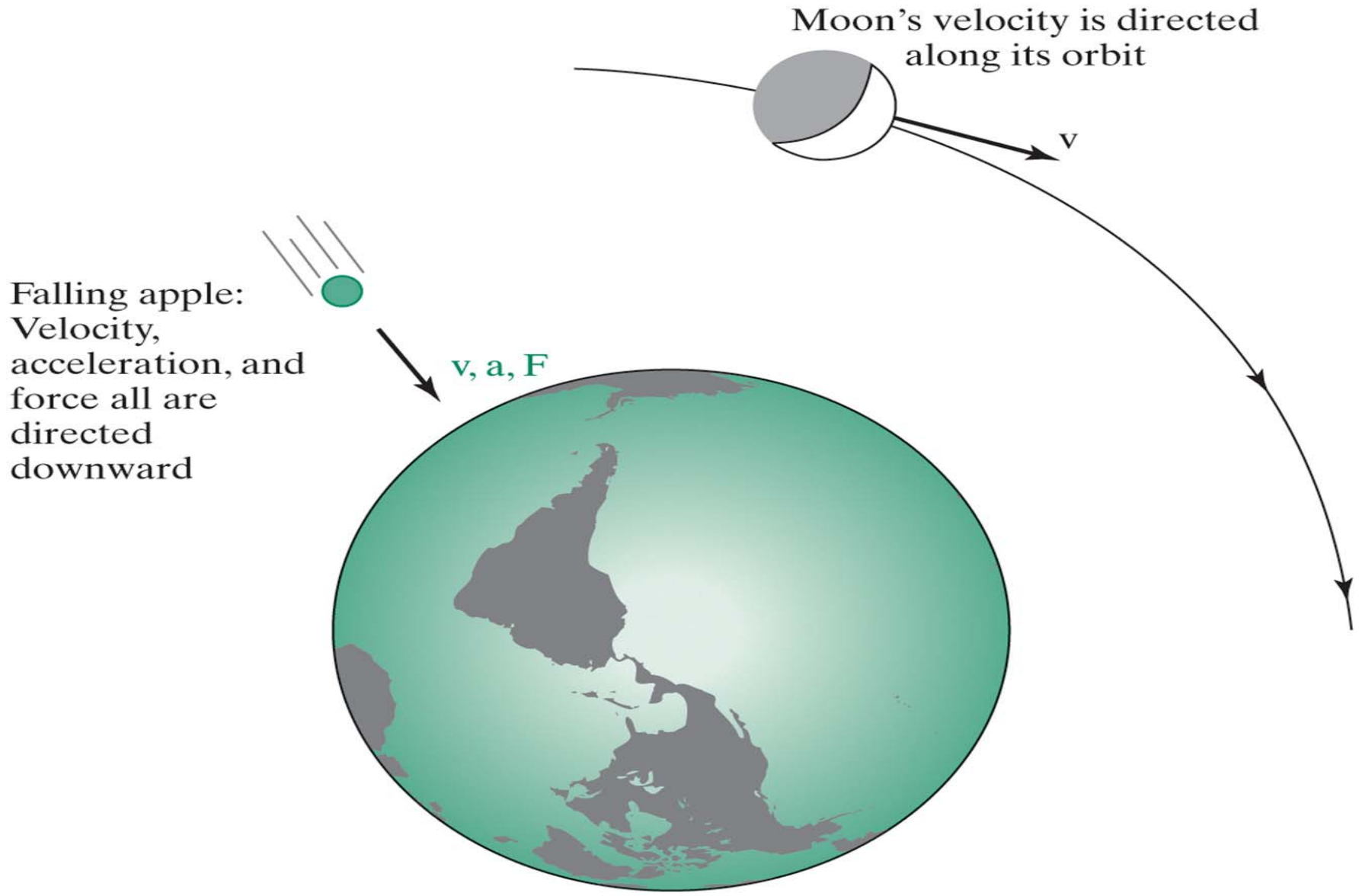
mass → "(rotational) moment of inertia" - (figure skater)
force → "torque" - force plus "lever arm"
momentum →"angular momentum" (& associated conservation law!)

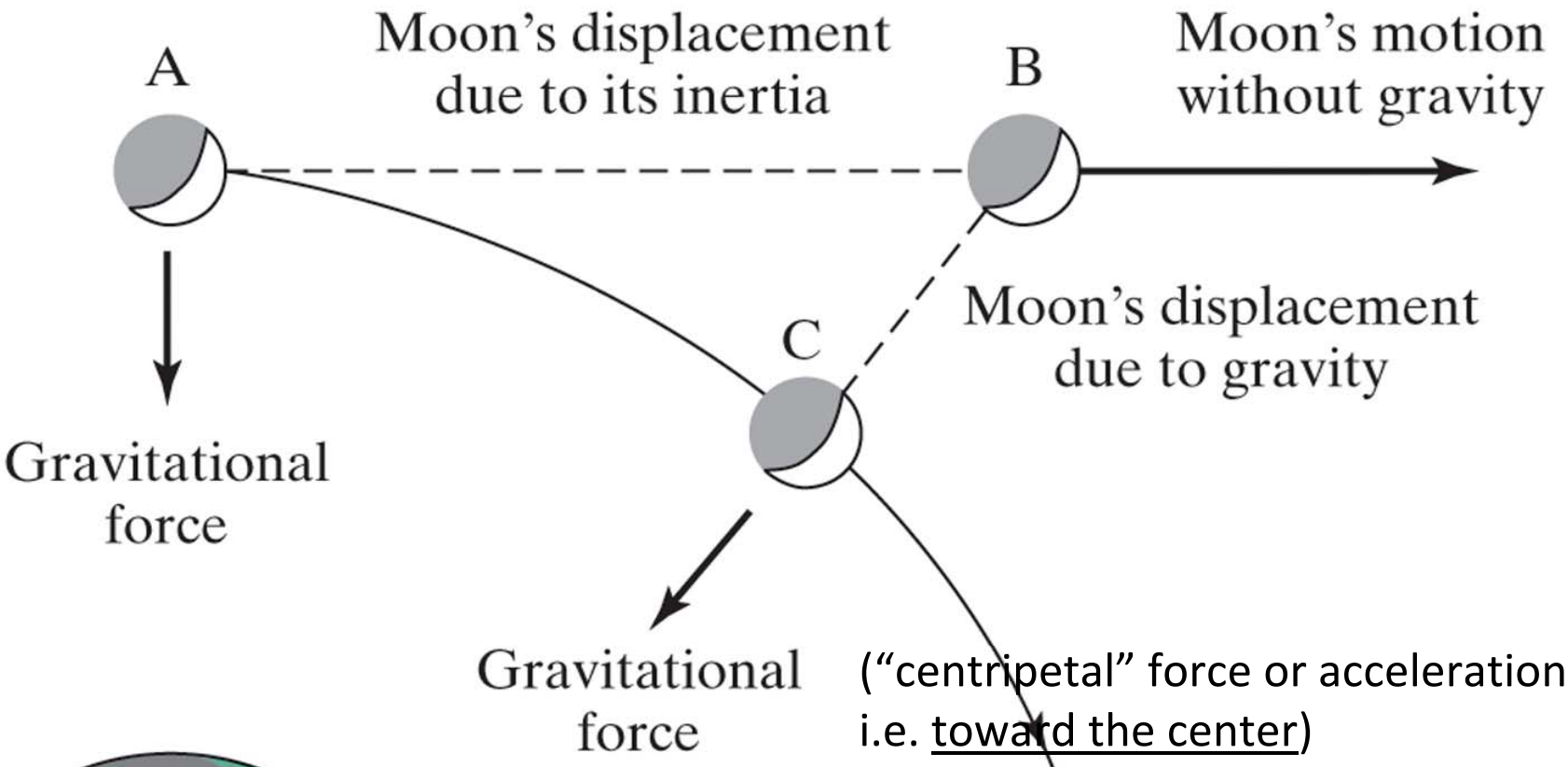
Demos

Chapter 5: Newtonian Gravity

Review Newtonian Gravity
Gravity in action

Newton's Gravity, a.k.a. "the apple and the moon", one of nature's fundamental forces (only 4!!)





("centripetal" force or acceleration, i.e. toward the center)

Newton's brilliant insight: same force as falling apple!

Note: this is "action at a distance"!

In some sense the moon is in "constant free fall" around Earth....with a speed of about 1 m/s and an acceleration of only about 0.0027 m/s^2.