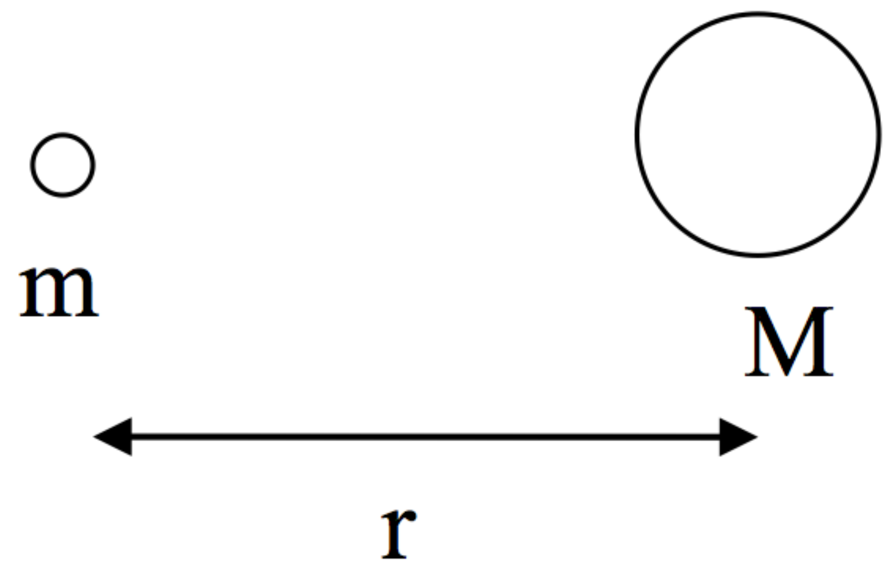
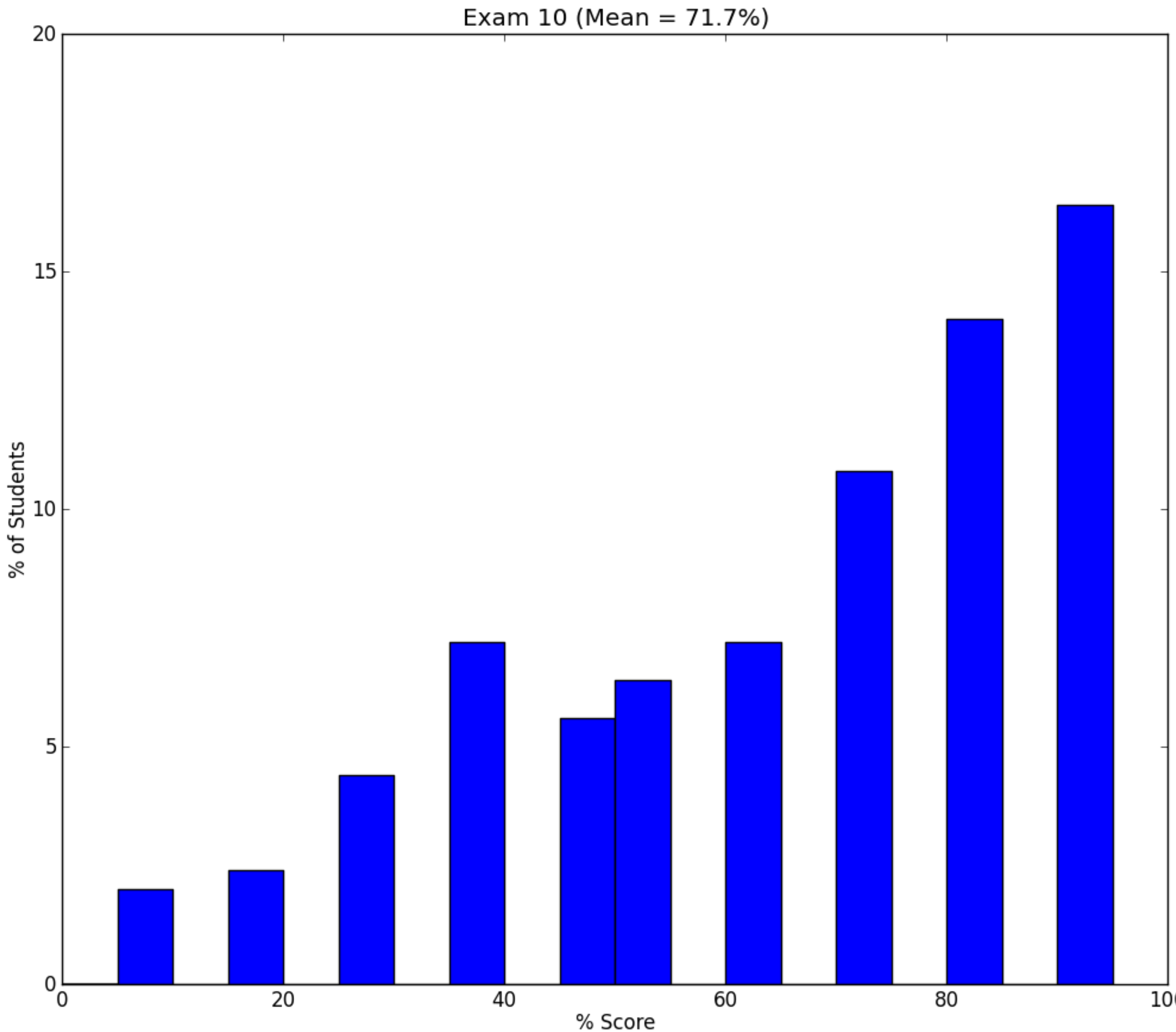
12-1) Two spherical masses m and M are a distance r apart. The distance between their centers is halved (decreased by a factor of 2). What happens to the magnitude of the force of gravity between them? The force increases by a factor of:

A) sqrt(2) ≈ 1.41
B) 2
C) 2*sqrt(2) ≈ 2.82
D) 4
E) 8



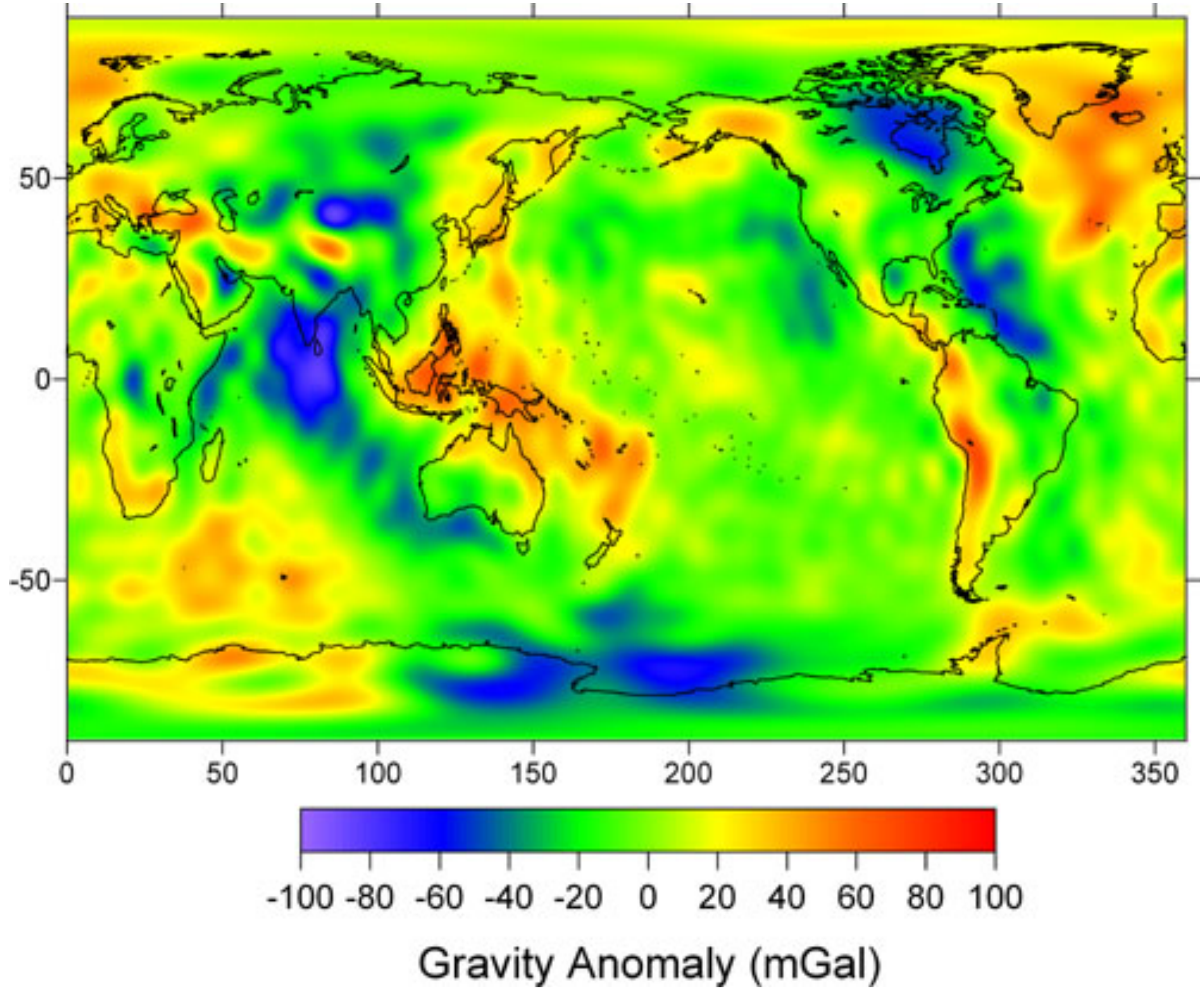
Announcements

- Final Exam information posted on LON-CAPA
  - Thursday, December 12th, 8pm-10pm
- Homework set 13 covers chapters 14 and 15
  - Due December 6th (no HW due over Thanksgiving)
- We have class Wednesday, November 27th
  - Clickers will be collected; Topic: oscillations

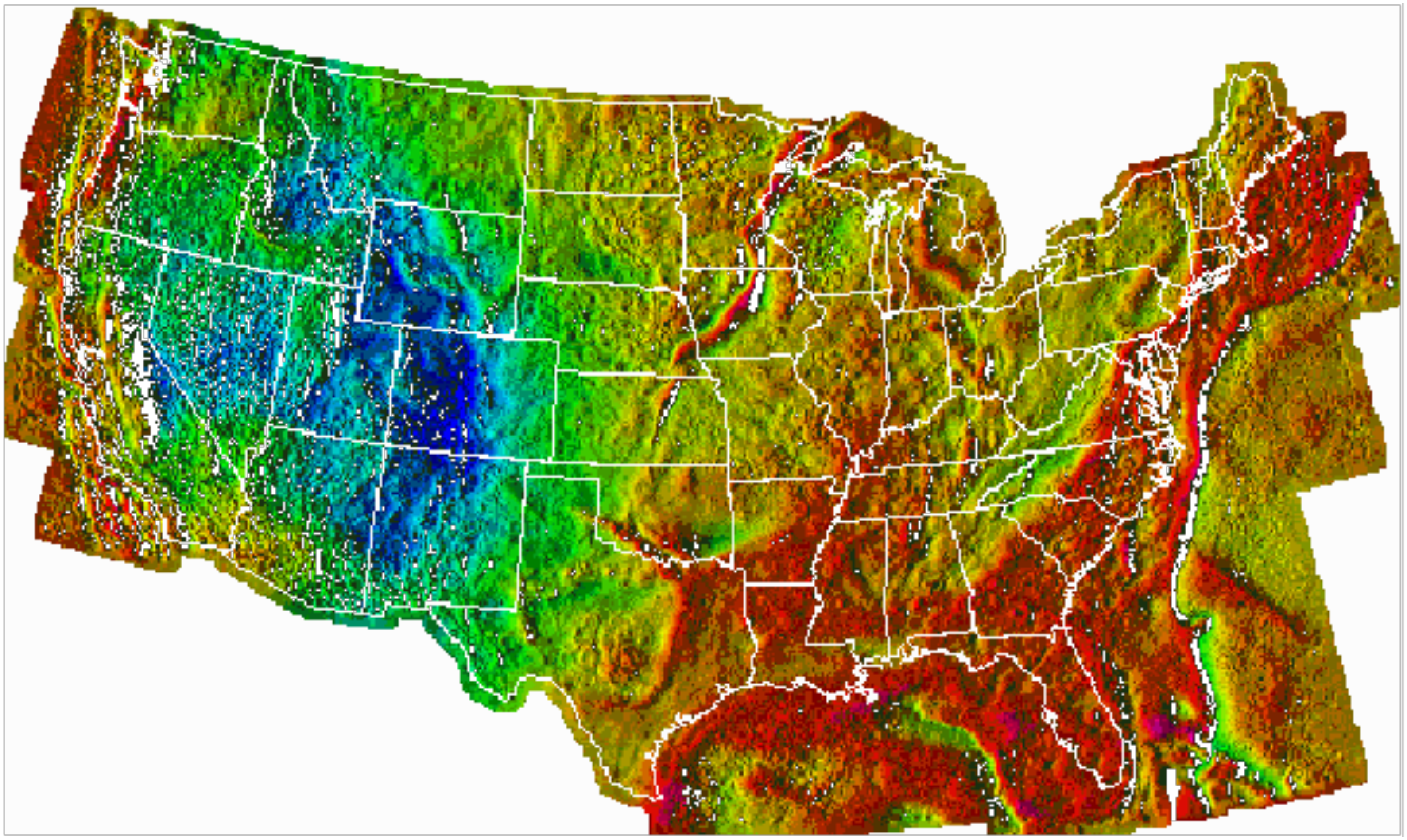


Exam 10 (Mean = 71.7%)
% of Students
% Score
0
5
10
15
20
0
20
40
60
80
100

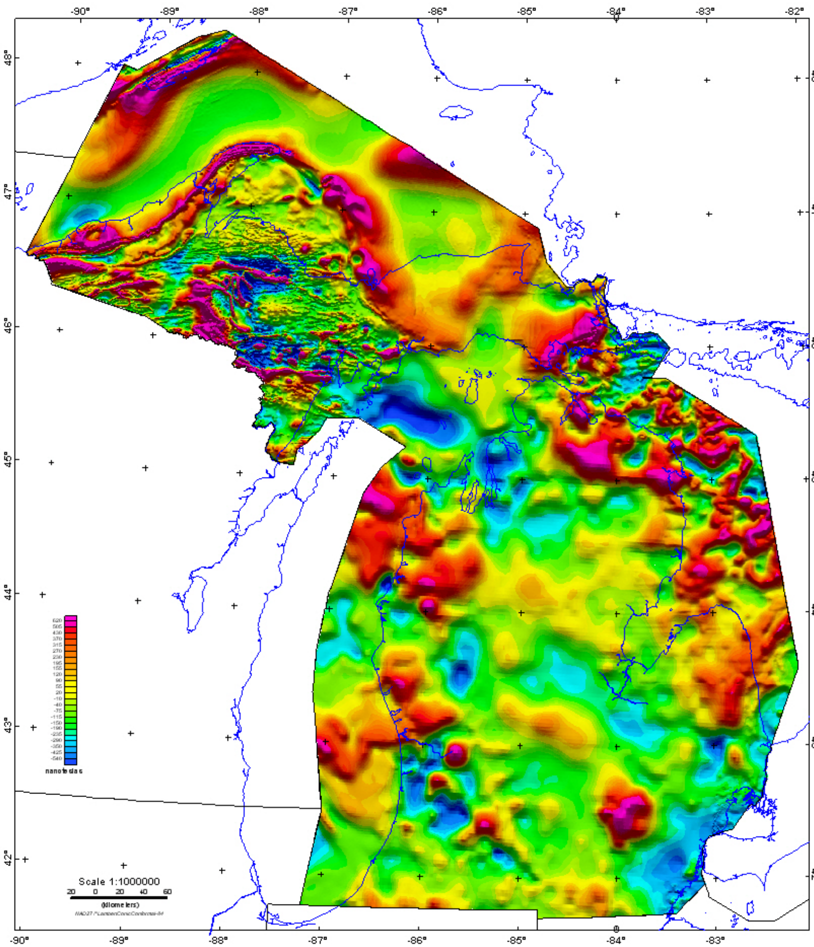
Gravity


50
0
-50
0
50
100
150
200
250
300
350
-100
-80
-60
-40
-20
0
20
40
60
80
100
Gravity Anomaly (mGal)

Gravity



Gravity


-90°
-89°
-88°
-87°
-86°
-85°
-84°
-83°
-82°
48°
47°
46°
45°
44°
43°
42°
Scale 1:1000000
20 0 20 40 60
(kilometers)

Gravity

Mystery Spot
(where water runs uphill)
St. Ignace, MI
http://www.mysteryspotstignace.com

Isaac Newton (1642 – 1727)

1689 - Age 47

1702 - Age 60

1725 – Age 83

Average Life Expectancy 40-45

12-1) Two spherical masses m and M are a distance r apart. The distance between their centers is halved (decreased by a factor of 2). What happens to the magnitude of the force of gravity between them? The force increases by a factor of:

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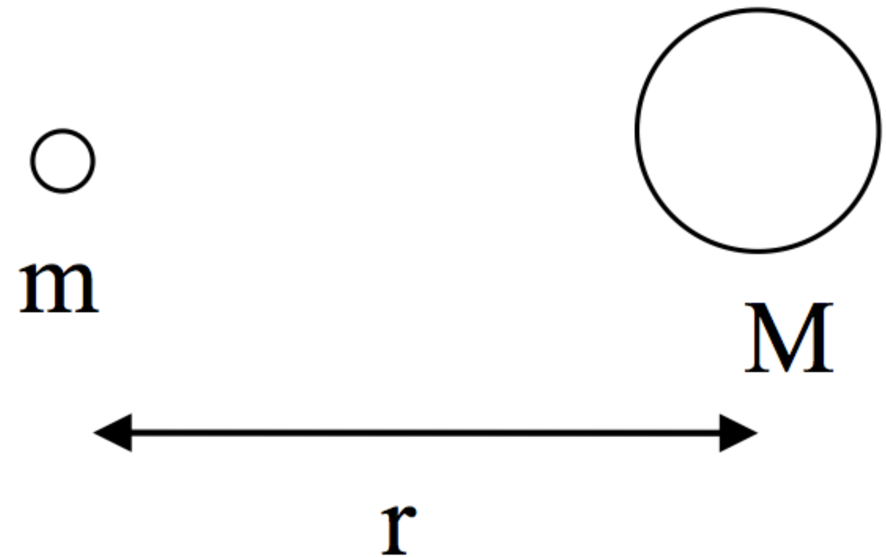
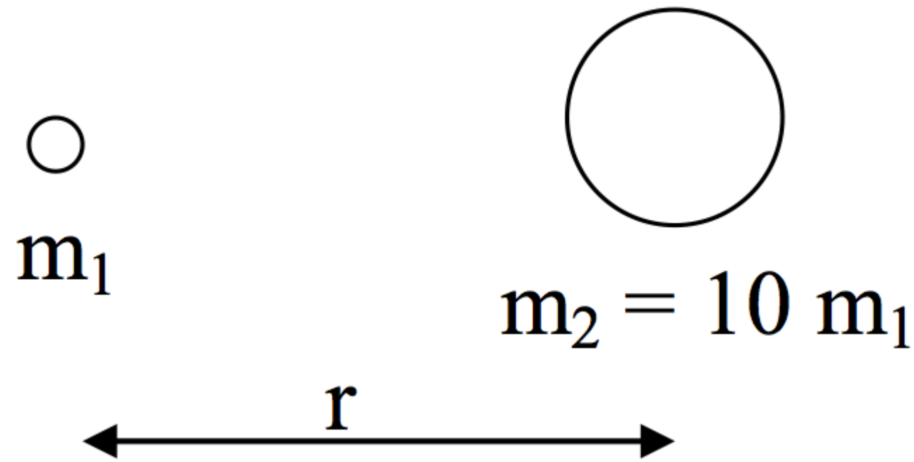
C) 2*sqrt(2) ≈ 2.82
D) 4
E) 8



12-2) At a particular instant, two asteroids in inter-galactic space are a distance r = 20 km apart. Asteroid 2 has 10 times the mass of asteroid 1. The magnitudes of the accelerations of asteroids 1 and 2 are a_1 and a_2, respectively.

What is the ratio a_1/a_2?

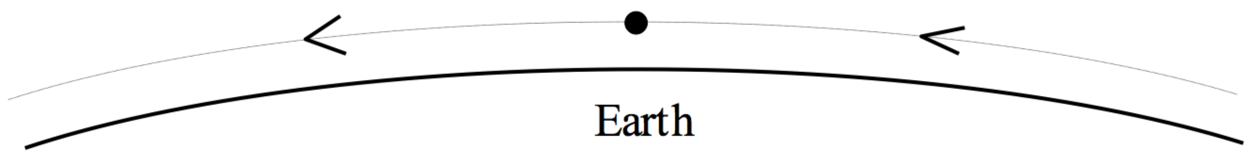
A) 10
B) 1/10
C) 1
D) Cannot be determined



12-3) Planet X has the same mass as the Earth, but 1/2 the radius. (Planet X is more dense than Earth). What is the acceleration of gravity on Planet X?

A) g_E (same as Earth)
B) 2 g_E
C) 4 g_E
D) 8 g_E
E) None of these

12-4) A satellite is in circular orbit at an altitude of 100 miles above the surface of the Earth.



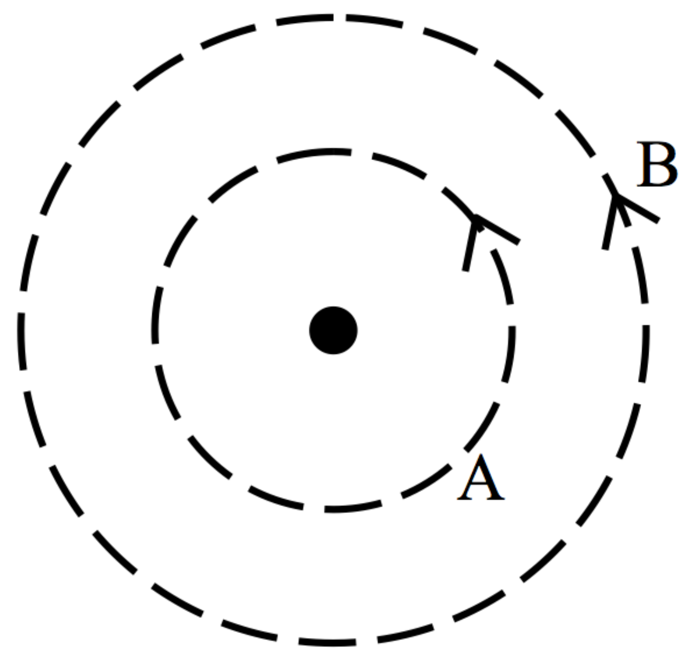
The satellite's pre-launch weight is its weight measured on the ground. The magnitude of the force of gravity on the satellite while it is in orbit is…

A) slightly greater than its pre-launch weight.
B) the same as its pre-launch weight.
C) slightly less than its pre-launch weight.
D) much less than its pre-launch weight, but not zero.
E) zero.

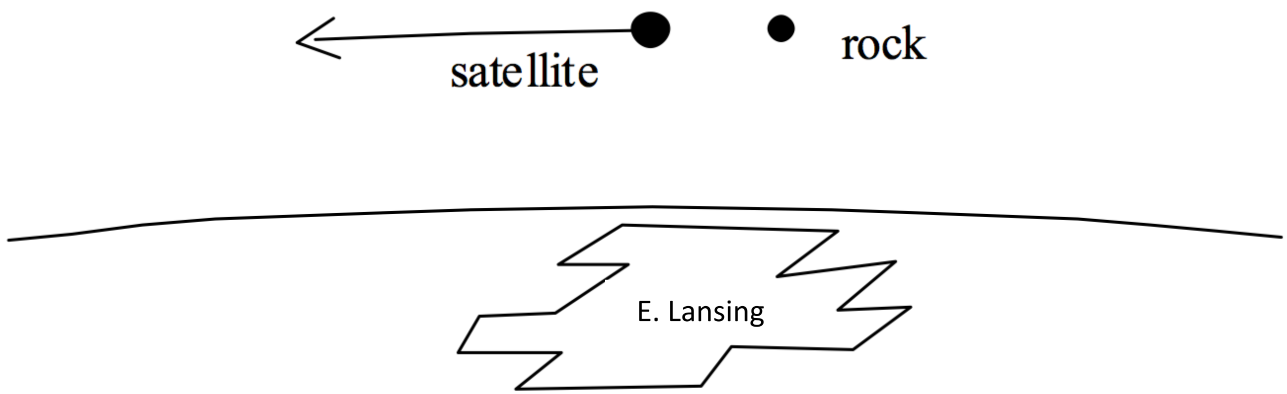
12-5) Two satellites, A and B, are in circular orbit around the earth. The distance of satellite B from the center of the Earth is twice that of satellite A. What is the ratio of the magnitudes of the accelerations of A to B?

$a_A/a_B = \ldots$

A) 1
B) 2
C) 4
D) 1/2
E) 1/4



12-7) At time t=0, a satellite in circular orbit about the Earth is directly over East Lansing, 300 miles above the city, and traveling eastward at 16,000 mph. At the same time, a rock is released from rest 300 miles above the city, very near the satellite.

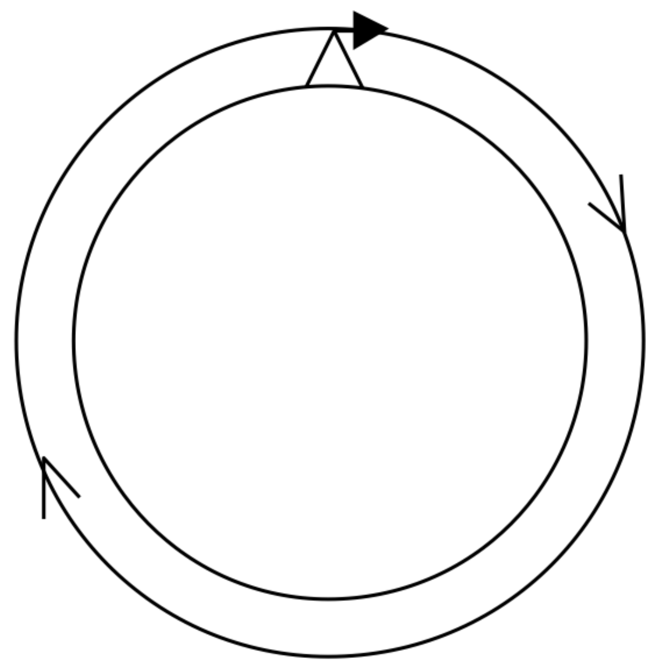


True or False: at t=0+, the acceleration of the rock and the satellite are identical.

A) True B) False

12-8) Suppose the Earth had no atmosphere and a projectile was fired from a mountain top with sufficient speed to put it in circular orbit. The magnitude of the acceleration of the projectile while in orbit would be …

A) much less than g (because it doesn't fall to the ground)
B) much greater than g
C) approximately g
D) Impossible to tell.



Johannes Kepler (1571 – 1630)

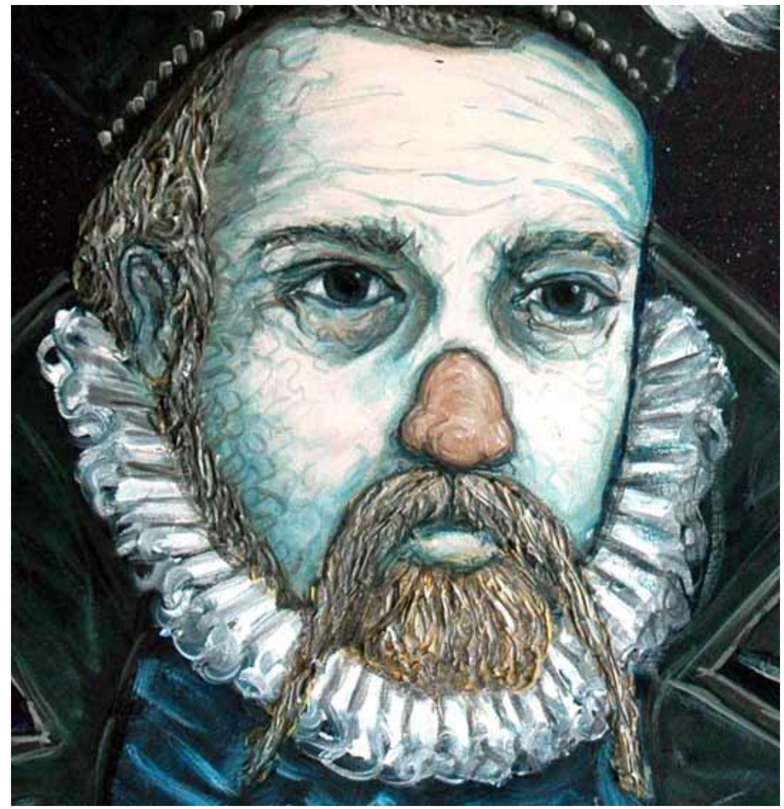
~1594 – Age 23

1610 - Age 39

>1620 - > Age 50

Tycho Brahe (1546 – 1601)

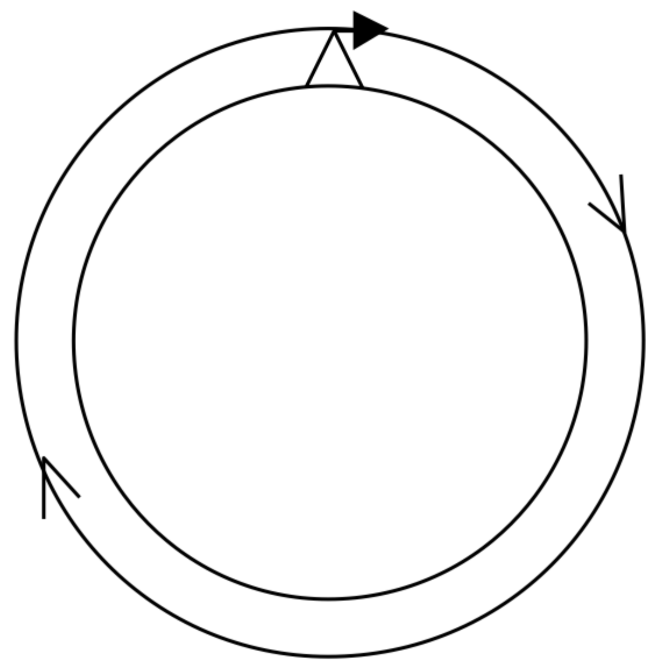
<1566 – < Age 20



>1566 – > Age 20

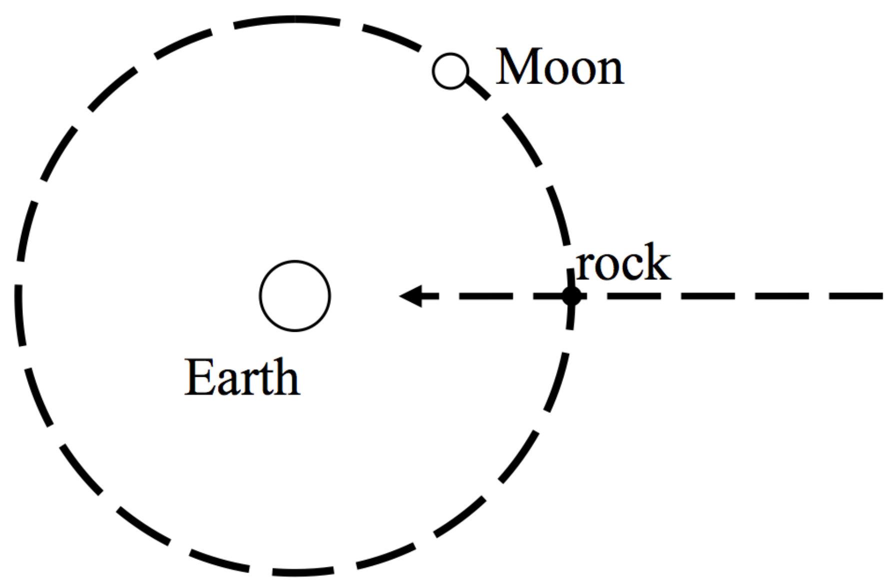
12-8) Suppose the Earth had no atmosphere and a projectile was fired from a mountain top with sufficient speed to put it in circular orbit. The magnitude of the acceleration of the projectile while in orbit would be …

A) much less than g (because it doesn't fall to the ground)
B) much greater than g
C) approximately g
D) Impossible to tell.



12-6a) A rock is released from rest at a point in space far from Earth, beyond the orbit of the Moon. The rock falls toward the Earth and crosses the orbit of the Moon. When the rock is the same distance from the Earth as the Moon, the magnitude of the acceleration of the rock is ___________ the acceleration of the Moon.
(Ignore the gravitational force between the rock and the Moon.)

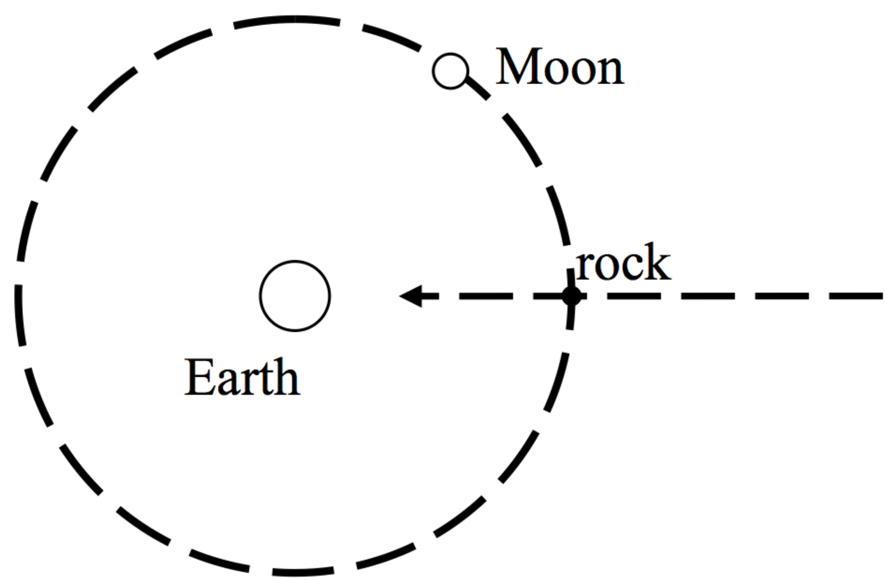
A) greater
B) smaller
C) the same as



12-6b) As the rock falls toward the Earth, its acceleration is … (neglect Moon's gravity)

A) constant.

B) not constant.

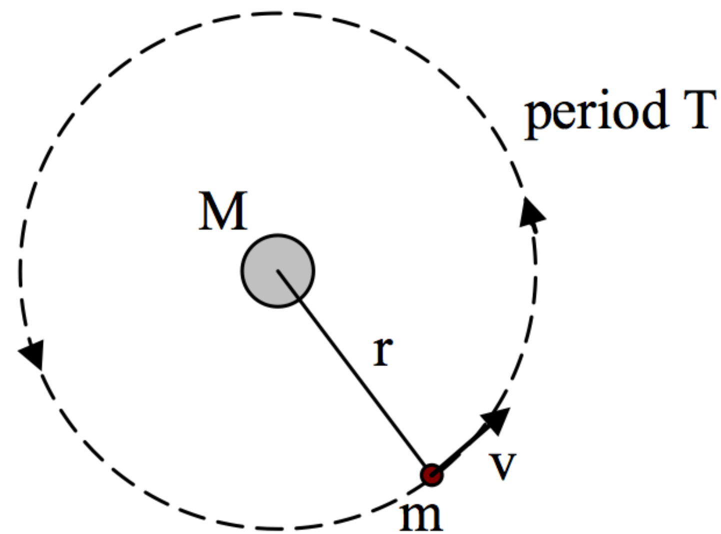


12-9) Kepler's third law states that the ratio T^2/r^3 is a constant for all the planets. The period T of the Earth is 1 year. An astronomical unit (1 A.U.) is defined as the mean distance from the Earth to the Sun, therefore the mean Earth-Sun distance is 1A.U. Consider an asteroid in circular orbit around the Sun with radius r = 2A.U. The period of the asteroid is …

A) 2 years
B) 3 years
C) $2^{3/2} \cong 2.83$ years
D) $2^{2/3} \cong 1.59$ years
E) None of these.

Example: Kepler's 3rd from Newton's 2nd

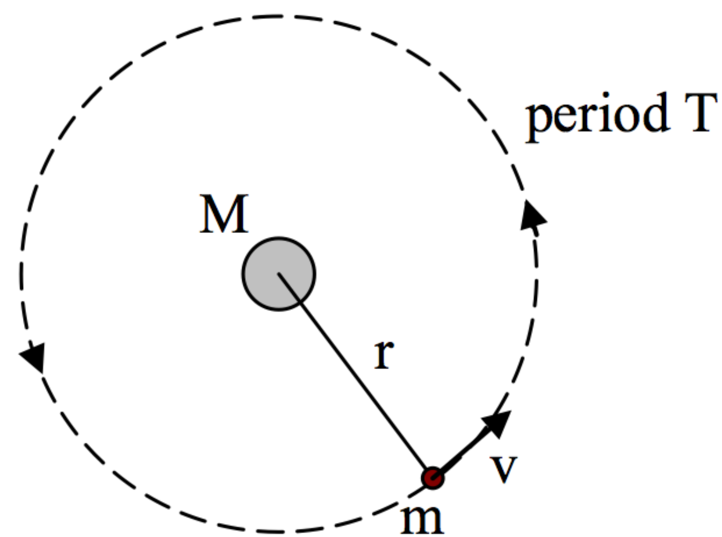
Consider a small mass, m, orbiting a larger mass, M, in a circle orbit at constant speed. The masses are separated by r and the orbital period is T. We want to show that T^2/r^3 is a constant.



Example: Kepler's 3rd from Newton's 2nd

12-20a) What is the acceleration the small experiences?

A) v/r
B) v^2/r
C) v/r^2
D) v^2/r^2
E) Something else



Example: Kepler's 3rd from Newton's 2nd

12-20b) The net force that the small mass experiences is equal to:

I. ma

II. mv^2/r

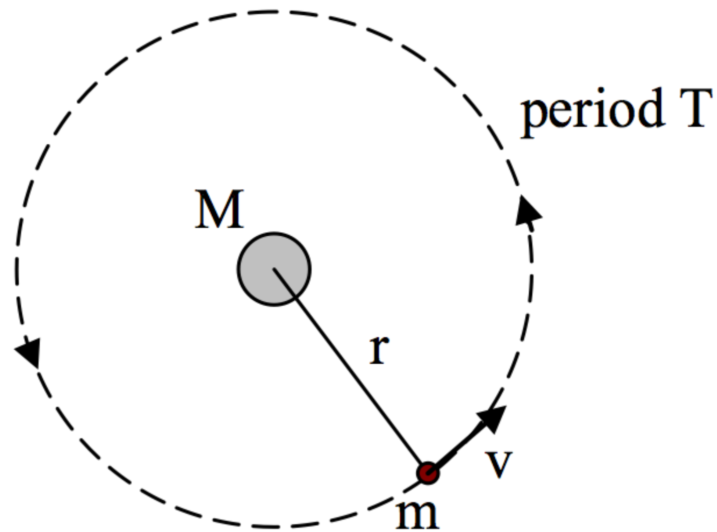
III. GMm/r^2

A) None of these

B) One of these

C) Two of these

D) All of these



Example: Kepler's 3rd from Newton's 2nd

12-20c) The speed of the little mass is equal to:

I. sqrt(GM/r)

II. r/T

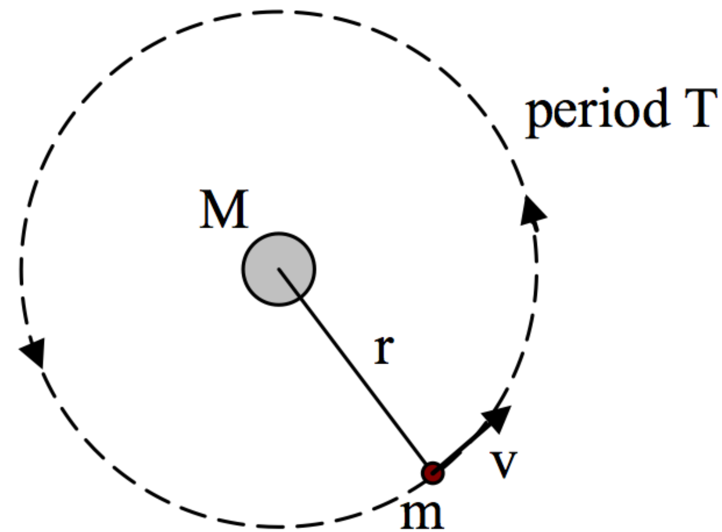
III. 2πr/T

A) None of these

B) One of these

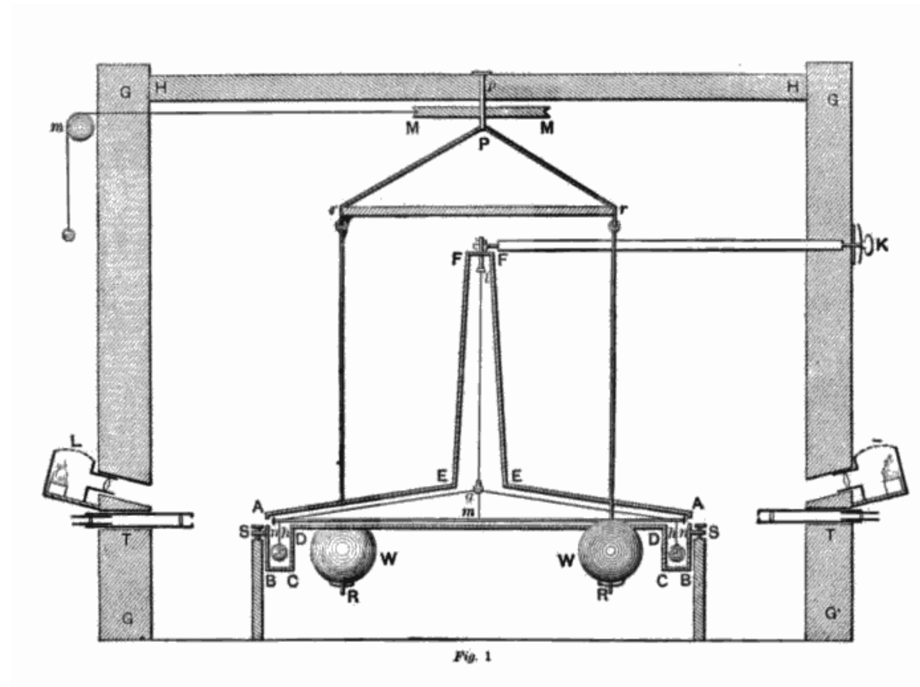
C) Two of these

D) All of these



Henry Cavendish (1731-1810)

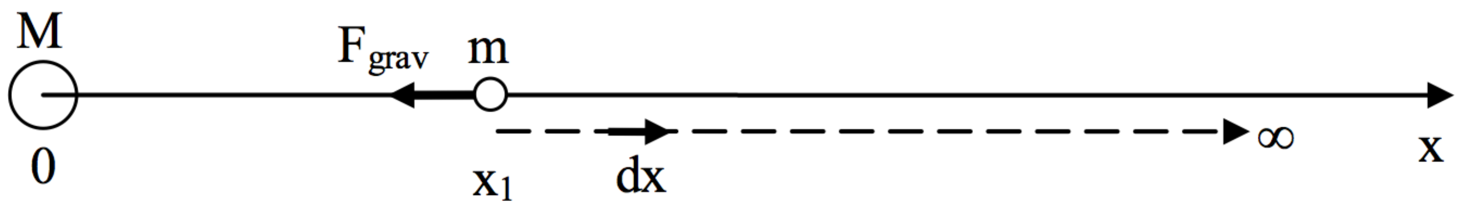
The man



The experiment

Example: What is the gravitational PE?

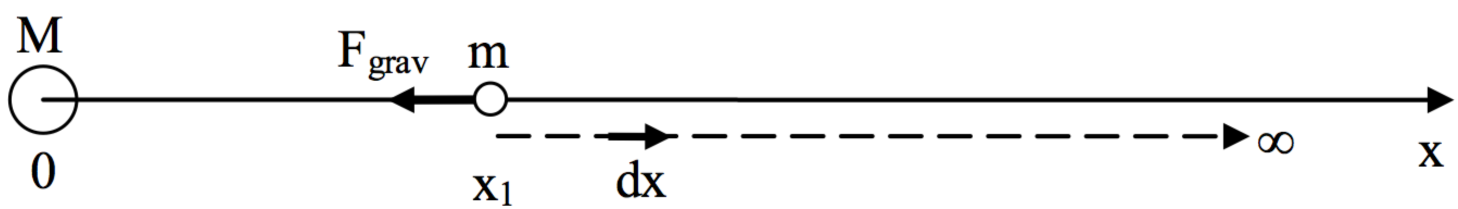
12-21a) Which describes the 1D gravitational force in this figure. (+x is to the right).



A) $F_{grav} = -GMm/x^2$
B) $F_{grav} = +GMm/x^2$
C) Something else

Example: What is the gravitational PE?

12-21b) The move the little mass m from x_1 to ∞ the force of gravity does _______ work.



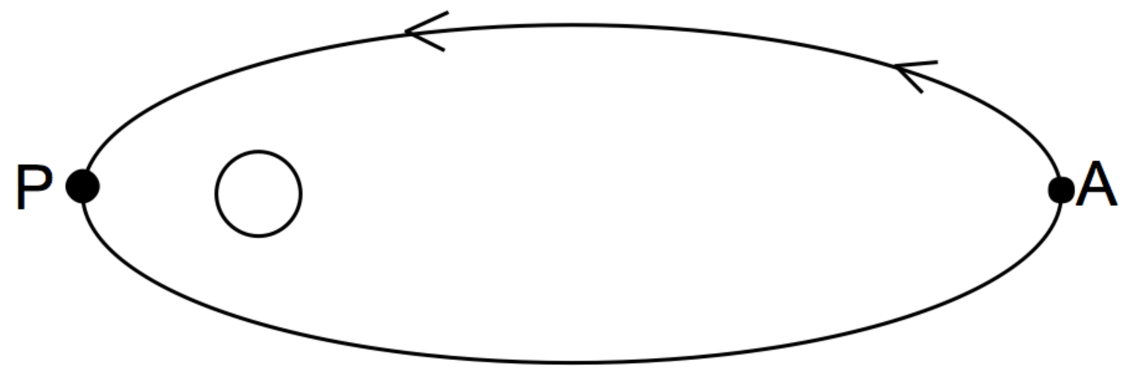
A) no

B) positive

C) negative

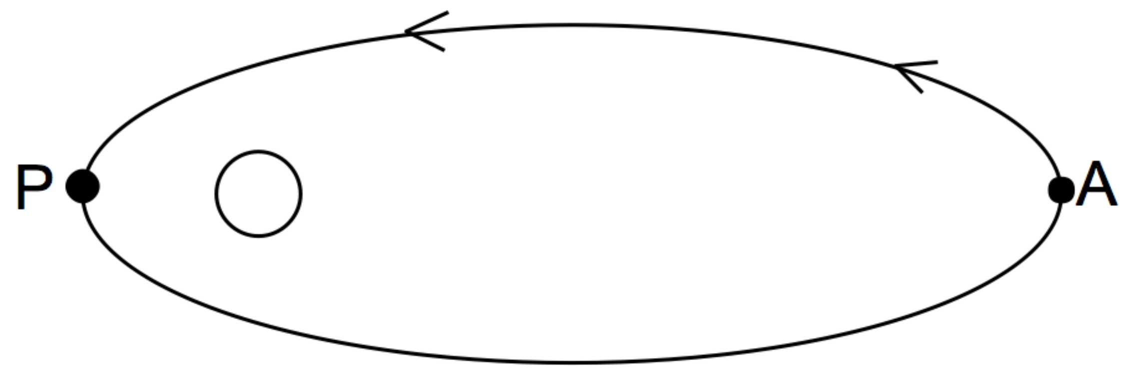
12-10a) A planet in elliptical orbit around a star moves from the point in its orbit furthest from the star (A) to the closest point (P). The work done by the force of gravity during this movement is:

A) zero.
B) positive.
C) negative.



12-10b) The planet executes one complete orbit starting from point A and returning to A. The work done by the force of gravity during this orbit is:

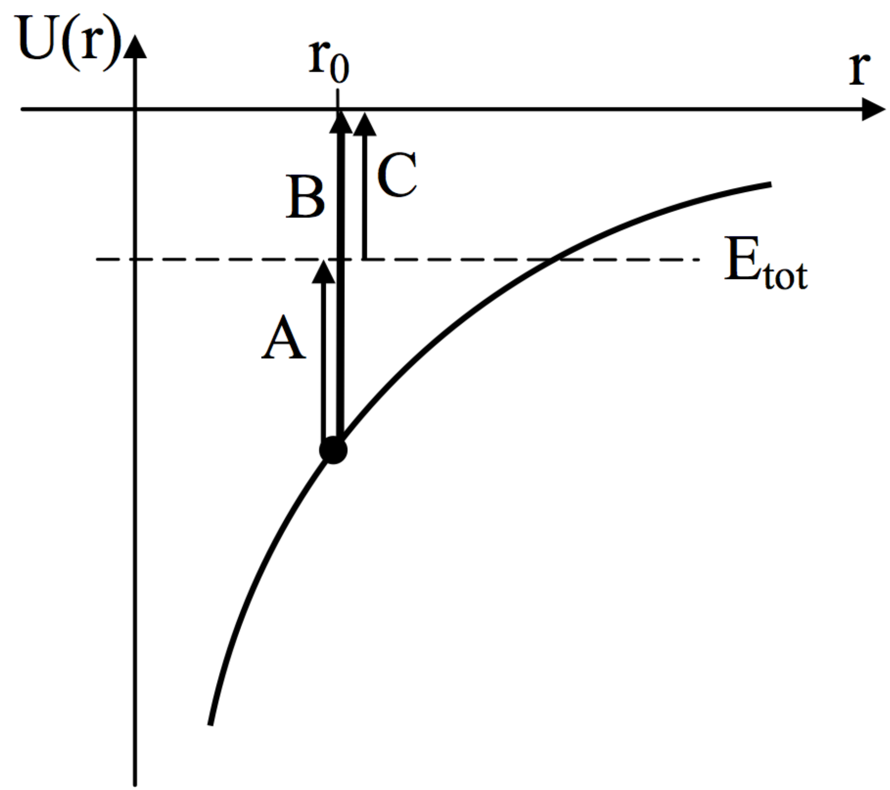
A) zero.
B) positive.
C) negative.



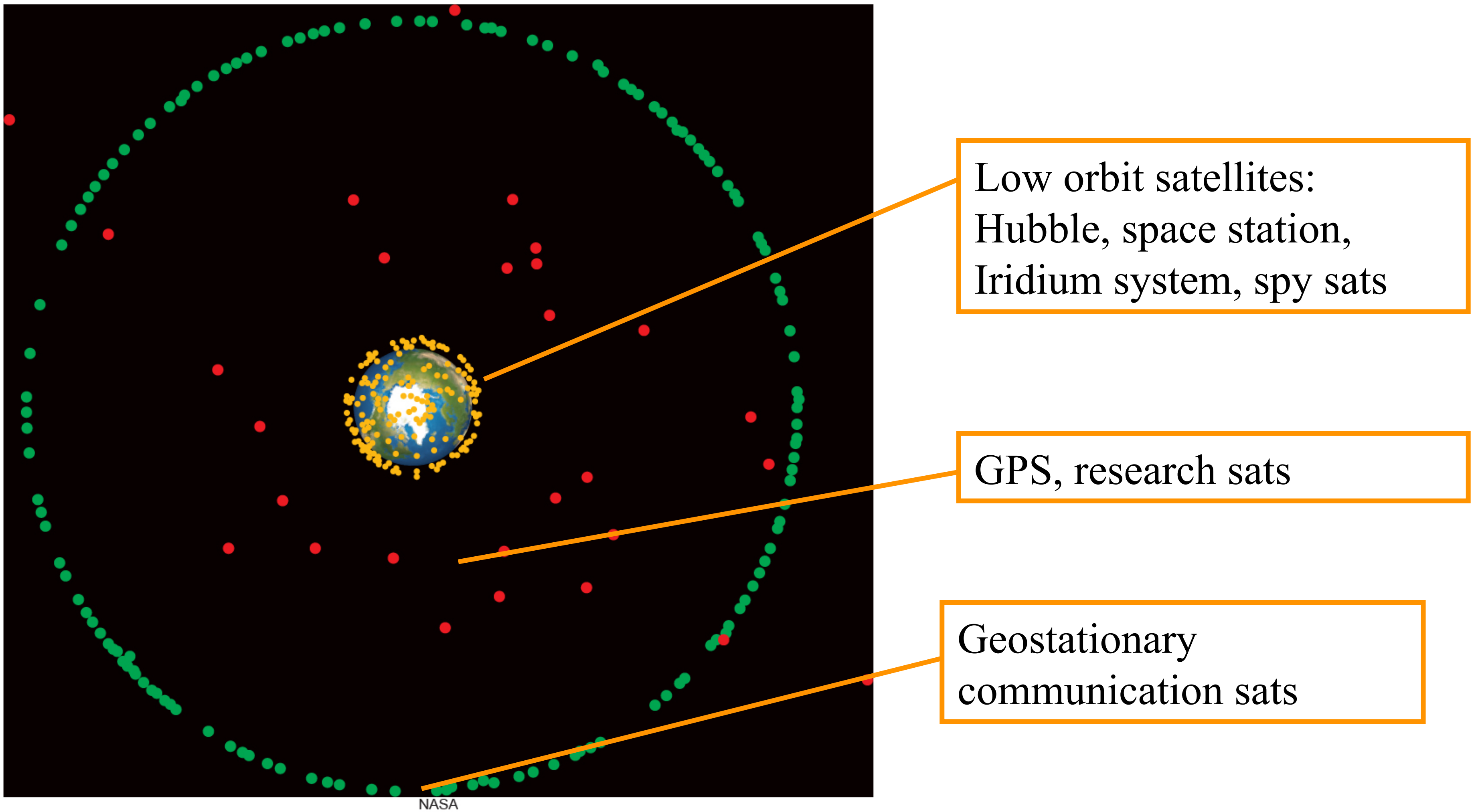
12-11) The gravitational PE, $U(r) = -GMm/r$ of a two mass system ($m << M$) is plotted. Mass M is stationary at the origin and mass m is at $r = r_0$. Also shown is the total energy E_{tot}.

Which arrow represents the KE of mass m?

A B C D) none of these



Geosynchronous Orbits



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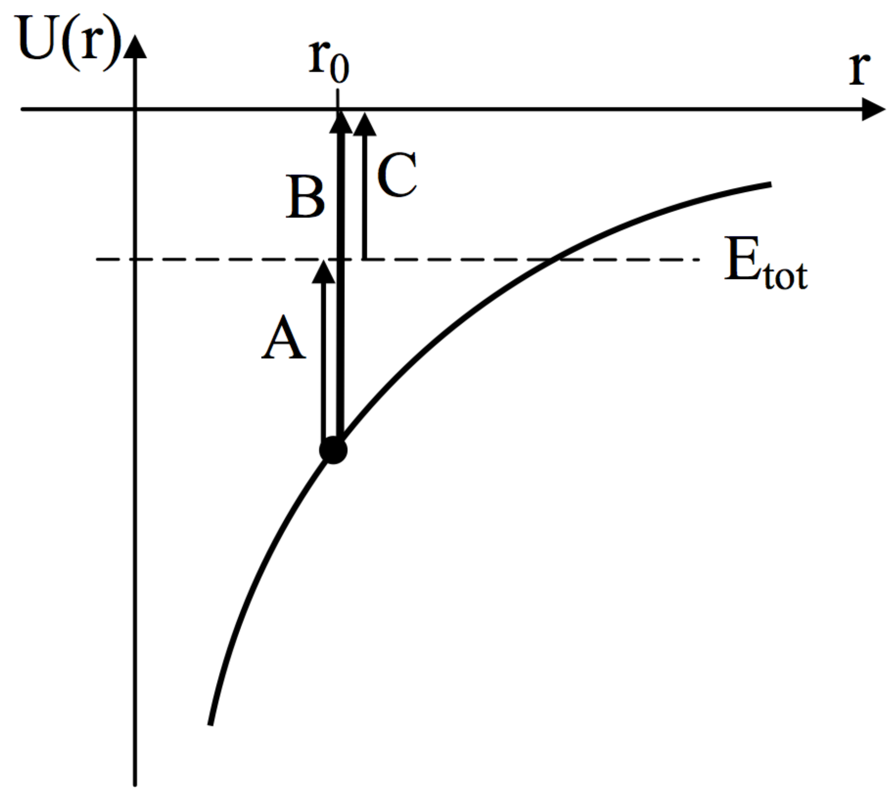
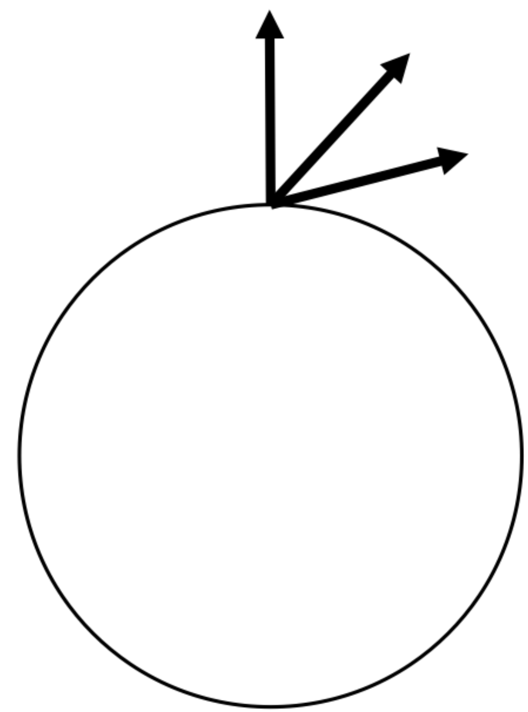


12-12) A projectile is fired from an airless world with a speed = v_{escape}. What is the total energy (E_{tot} = KE – GMm/r) of the projectile?

A) $E_{tot} = 0$
B) $E_{tot} < 0$
C) $E_{tot} > 0$

12-13) Does escape speed depend on launch angle? That is, if a projectile is given an initial speed v_0, is it more likely to escape an (airless) planet, if fired straight up than if fired at an angle?

A) Yes
B) No

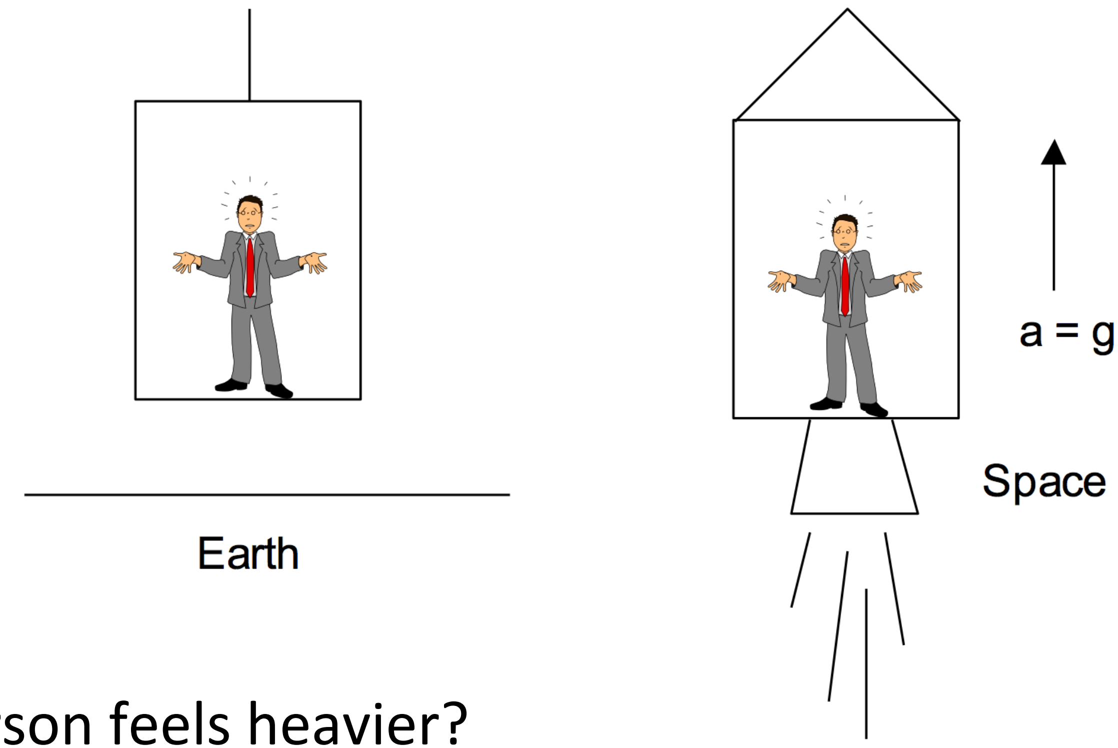


12-19) How does the force of gravity on a space shuttle Astronaut compare to the force of gravity on the astronaut when she is on the earth?

A) Force of gravity on the space shuttle astronaut is zero.
B) Force of gravity on the space shuttle astronaut is much, much less than on earth, but not zero.
C) Force of gravity on the space shuttle astronaut is slightly less than when on earth.

12-17) A person is standing in an elevator in a building on Earth. The elevator is stopped between floors.

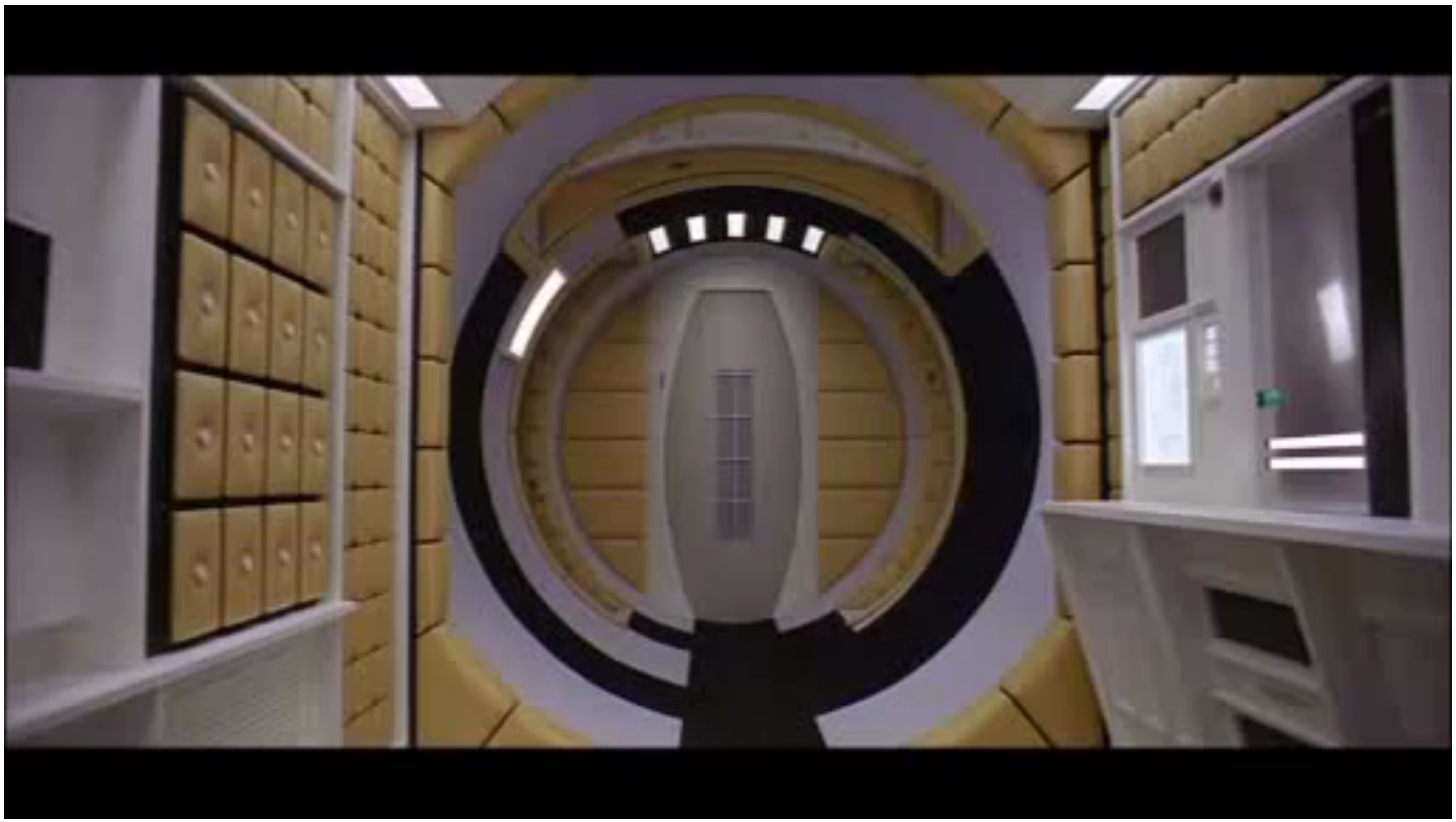
Another person is in a small room in a rocket in intergalactic space. The rocket is accelerating at 9.8 m/s^2 as shown.



Which person feels heavier?

A) Earth person B) Space person C) The feel exactly the same

2001: A Space Odyssey (1968)



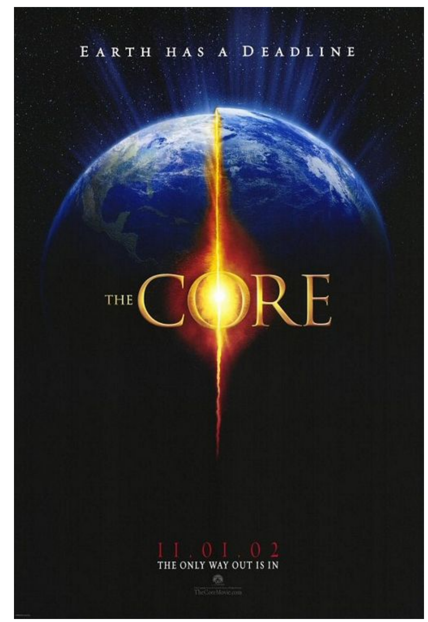
http://www.youtube.com/watch?v=0iiXUeil5fQ
This is one of the greatest films ever made. Honestly, rent it.

12-18) Astronaut Dave Bowman is standing in the centrifuge of the spaceship Discovery. He drops his pen and observes it fall to the floor. Which statement below is most accurate?

A) After Bowman releases the pen, the net force on the pen is zero.
B) The pen falls because the centrifugal force pulls it toward the floor.
C) The pen falls because the artificial gravity pulls it toward the floor.

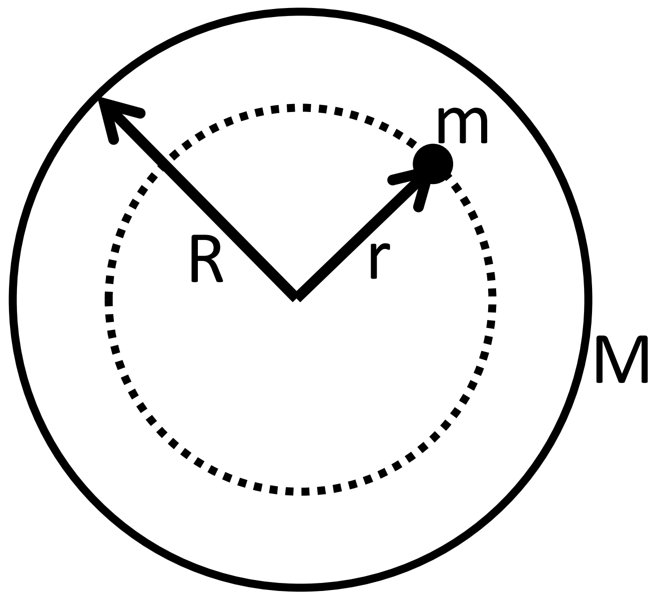
Example: Gravity inside the Earth

Take some time over break and rent one of the worst movies out there.



Example: Gravity inside the Earth

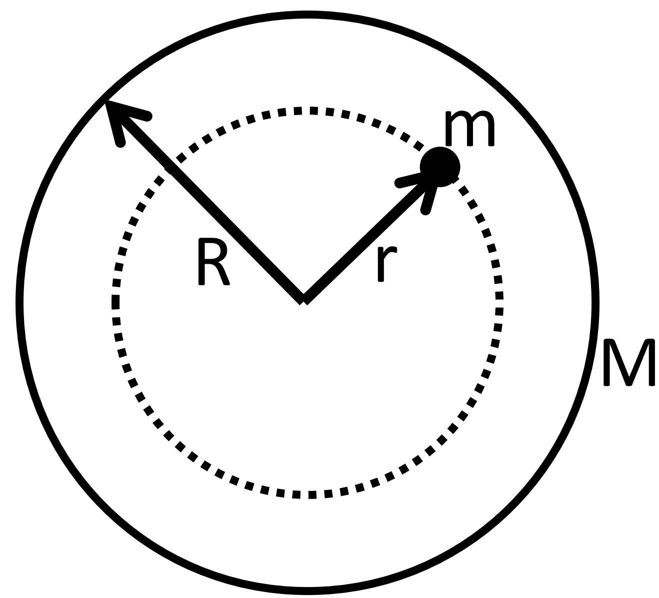
Consider a planet of mass M and radius R. It has a constant density $\rho = M/(4/3\pi R^3)$. You (mass, m) are somewhere inside of it a distance r from the center.



Example: Gravity inside the Earth

12-22a) Sitting inside the Earth, what affects the gravitational force that you feel?

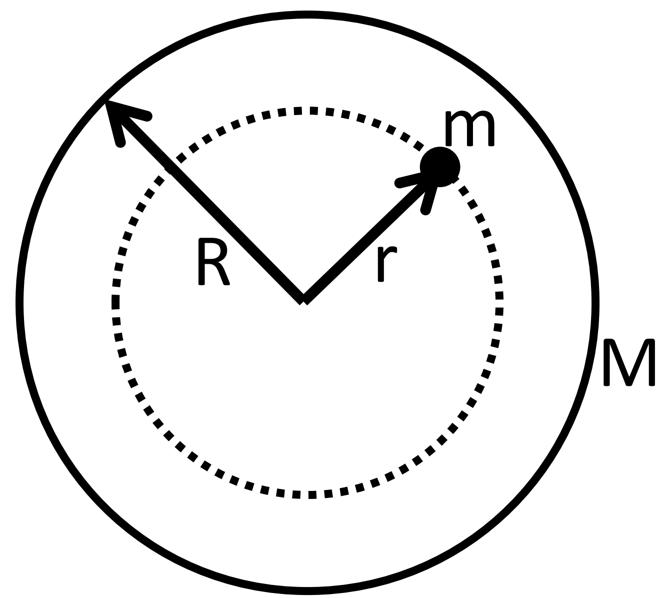
A) The mass inside r
B) The mass between r and R
C) All the mass



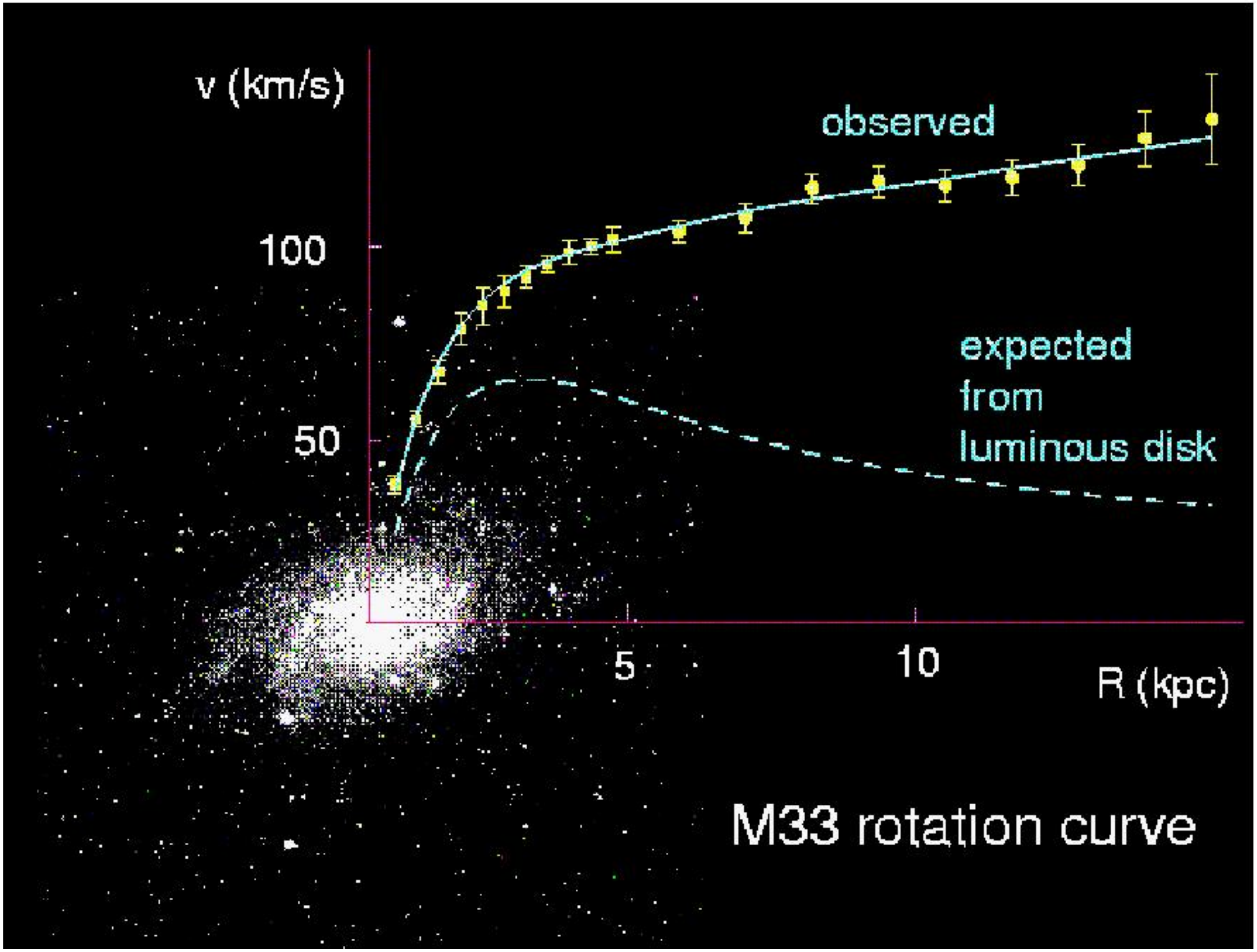
Example: Gravity inside the Earth

12-22b) Given that $F_{grav} = GmM_{enclosed}/r^2$, how does F_{grav} inside the Earth depend on r?

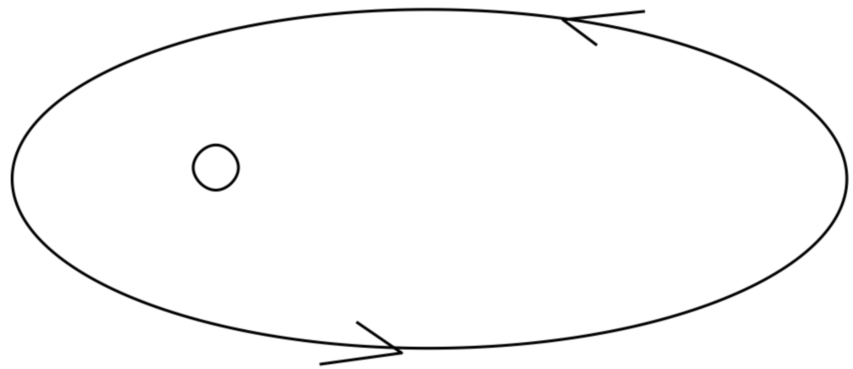
A) $F_{grav} \sim r^2$
B) $F_{grav} \sim r$
C) $F_{grav} \sim 1/r$
D) $F_{grav} \sim 1/r^2$
E) Something else



What's going on here?



12-14) A planet is in elliptical orbit around the Sun. The zero of potential energy U is chosen at $r = \infty$, so $U(r) = -GMm/r$.



How does the <u>magnitude</u> of U ($|U| = -U$) compare to the KE?

A) $|U| > KE$
B) $|U| < KE$
C) $|U| = KE$
D) depends on the position in the orbit.

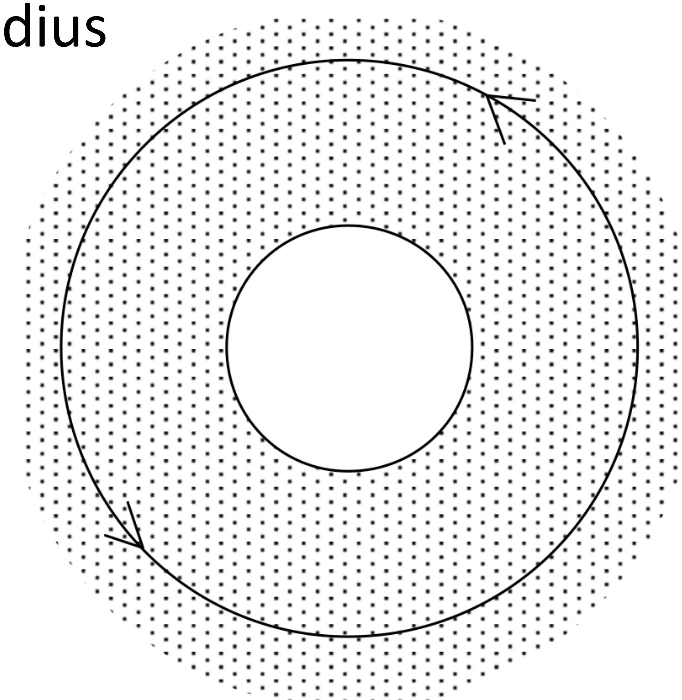
12-15) Suppose a projectile is fired straight upward from the surface of an airless planet of radius R with the escape velocity v_{esc} (meaning the projectile will just barely escape the planet's gravity – it will asymptotically approach infinite distance and zero speed.) What is the projectile's speed when it is a distance 4R from the planet's center (3R from the surface)?

A) 1/2 v_{esc}
B) 1/4 v_{esc}
C) 1/9 v_{esc}
D) 1/3 v_{esc}
E) None of these is correct.

(Ignore the gravity of the Sun and other astronomical bodies.)

12-16a) A satellite is in circular orbit around a planet that has a very tenuous atmosphere extending up to the altitude of the satellite. Due to atmospheric drag, the satellite …

A) spirals inward
B) spirals outward
C) remains in an orbit of constant radius



12-16b) As the orbit decays, the speed of the satellite…

A) increases
B) decreases
C) remains constant