

Review for Midterm 1

- Midterm 1 is Friday Mar 9
- On the eight chapters 2, 3, 4, 5, 6, 7, 8, 9
(we'll cover Ch 9 on Mar 1 – see first page of Lec. 8 for plan of next few lectures)
- Bring No. 2 pencil for bubble-sheet and an eraser
- 40 multiple-choice questions
- I will hold extended office hours on morning of Fri Mar 9: best to email me to set up a time

Resources for studying:

- go through all questions, exercises, and examples we did during lectures
- revise “check yourself” in book
- additional questions in today's lecture
- email me if you have any questions or want to meet

Recall

- **Chapter 2:** Newton's 1st law, inertia, forces, e.g. gravitational (=weight), support force, equilibrium (sum of forces = 0)
- **Chapter 3:** Linear motion, speed (= distance/time), velocity (= speed with direction), acceleration(= rate of change of velocity), free-fall motion ($a = g$)
- **Chapter 4:** N's 2nd law, $F_{\text{net}} = ma$, weight = mg , weight vs mass, friction, non-free fall and air resistance, terminal velocity
- **Chapter 5:** N's 3rd law, action-reaction, vectors (– only at conceptual level)
- **Chapter 6:** Momentum(= mv), Impulse= $F t$ = change in momentum, external vs internal forces, momentum conservation when F_{net} on system =0, collisions
- **Chapter 7:** Energy, Kinetic energy = $\frac{1}{2} m v^2$, Potential energy, Grav. PE = mgh , Work = $F d$, change in KE = Work, Power = Work/time, Total energy conservation, machines
- **Chapter 8:** Rotation, linear/tangential speed vs angular/rotational speed, $v = r \omega$, rotational inertia I , torque = $F \times$ lever arm, angular momentum = $I \omega$, ang mom conservation, CM/CG, stability
- **Chapter 9:** Gravity: $F = G m_1 m_2 / d^2$, apparent weight = force exerting against supporting surface, tides, black holes

When in a subway car that suddenly stops, you lurch forward.
What's the best explanation for this?

- A) Because of Newton's 1st law – you have inertia.
- B) Because you have no acceleration
- C) Because of action-reaction forces between the car and you
- D) Because of the support force

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Answer A: Newton's 1st law says that objects (you) tend to keep moving in a straight line; inertia resists changes in motion

According to Newton's law of inertia, a rail road train in motion should continue going forever even if its engine is turned off. We never observe this because railroad trains

- A) move too slowly.
- B) must go up and down hills.
- C) are much too heavy.
- D) always have forces that oppose their motion

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- C) are much too heavy.
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Answer: D

How about if there was **no** friction and no air drag – then what would happen once the engine is turned off?

Then the train would be accelerating while the engine was on, and would stop accelerating once the engine is turned off – i.e would move at constant velocity.

A hockey puck is set in motion across a frozen pond. If ice friction and air resistance are neglected, the force required to keep the puck sliding at constant velocity is

- A) equal to the product of its mass times its weight.
- B) equal to its weight divided by its mass.
- C) zero.
- D) equal to its weight

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- C) zero.
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Answer: C, since no acceleration – so no net force

As you're sitting in your chair, your weight acts as a downward force on the chair. Why then does the chair not sink into the ground?

- A) because of its weight
- B) because it feels an upward directed support force from the ground it is pushing down on
- C) because of inertia – the resistance to changes in motion.
- D) because of momentum conservation.

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Answer: B, the chair is in equilibrium, there is zero net force on it. The gravitational force is equal and opposite to the upward support force.

A skier covers a distance of 3 m in half a second. What is his average speed?

- A) 1.5 m/s
- B) 3 m/s
- C) 6 m/s
- D) 9 m/s

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C) Average speed = distance/time = $3\text{m}/0.5\text{s} = 6\text{ m/s}$

As an object freely falls downward, its

A) velocity increases

B) acceleration increases.

C) both of these

D) none of these.

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D) none of these.

A) It accelerates at either (i) a constant rate $=g$, if there is negligible air resistance or (ii) gradually less acceleration if there is air resistance.

When a rock thrown upwards falls back down and passes the same point it was thrown from,

- a) its velocity is zero and its acceleration is zero
- b) its velocity is zero and its acceleration is about 10 meters per second per second
- c) its velocity is about 10 m/s and its acceleration is zero
- d) its velocity is negative of the initial velocity it was thrown up with and its acceleration is about 10 meters per second per second.

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Answer d) Note, acc. in free-fall (on earth) is *always*
 $g \sim 10 \text{ m/s}^2$

Half a second after starting from rest, a free-falling object will have a speed of about

- a) 10 m/s
- b) 20 m/s
- c) 5 m/s
- d) 0
- e) None of these

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Answer c) In free fall, object gains about 10m/s every second. So, in half a second, gain 5 m/s.

What if the free-falling object is moving upward at a speed of 20 m/s. What is its speed half a second later?

15 m/s

Two balls are thrown from the same point high on a cliff. One is thrown upwards and the other is merely dropped from rest. Neglecting air resistance, which has the higher acceleration?

- A) The ball thrown upwards
- B) The ball dropped from rest
- C) It depends on how fast the thrown ball was thrown
- D) It's the same for each
- E) None of these

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Answer: D, acceleration = g downwards

If a projectile is fired straight up at a speed of 10 m/s, the total time to return to its starting position is about

- A) 2 seconds.
- B) 10 seconds.
- C) 20 seconds.
- D) 1 second.
- E) not enough information to estimate

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Answer: A

Each second it loses about 10m/s so after 1s, it has zero velocity, i.e. is turning around. Then it gains 10m/s as it falls, so after another second (a total of 2 s) it has -10m/s i.e. same initial speed at which it began, hence returned to the same point.

A rock weighs 30 N on Earth. A second rock weighs 30 N on the moon. Which of the two rocks has the greater mass?

- A) the one on the moon
- B) the one on Earth
- C) They have the same mass.
- D) not enough information to say

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A) Because weight = mg , and g is less on moon, so m must be bigger to get the same weight of 30N

A 20-kg girl and her 40-kg big brother are each sitting on a sled, waiting to be pushed across the snow. To provide them with equal horizontal acceleration, we would have to push with

- A) equal forces
- B) twice as much force on the boy
- C) twice as much force on the girl
- D) four times as much force on the boy
- E) none of these

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- B) twice as much force on the boy
- C) twice as much force on the girl
- D) four times as much force on the boy
- E) none of these

Answer: B

Since $a = F_{net}/m$, an object with twice the mass requires twice the force in order to experience the same acceleration.

What horizontally-applied force will accelerate a 200-kg box at 1 m/s^2 across a floor against a friction force equal to one fifth of its weight?

- a) 200 N
- b) 400 N
- c) 600 N
- d) 2400 N
- e) None of these

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C) Weight = $mg = 2000 \text{ N}$. We're told friction = weight/5 = 400 N here.

$$F_{\text{net}} = F_{\text{applied}} - \text{friction} = ma$$

$$\text{So, } F_{\text{applied}} = ma + \text{friction} = 200 + 400 = 600 \text{ N}$$

A girl pulls on a 10-kg wagon with a constant horizontal force of 20 N. If there are no other horizontal forces, what is the wagon's acceleration in meters per second per second?

- A) 2.0
- B) 0.5
- C) 20
- D) 200
- E) None of the above

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- C) 20
- D) 200
- E) None of the above

Answer: A, since $a = F/m = 20/10 = 2 \text{ m/s}^2$

What if there was a friction force of 5 N?

Then $a = F/m = (20-5)/10 = 1.5 \text{ m/s}^2$

A large person and a small person wish to parachute at equal terminal velocities. The larger person will have to

- a) Jump first from the plane
- b) Pull upward on the supporting strands to decrease the downward net force
- c) Jump lightly
- d) Get a larger parachute
- e) Get a smaller parachute

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d) If he does nothing, the larger person would accelerate for longer and have a larger terminal velocity. So he needs to do something to decrease this and effectively increase air resistance – i.e. get larger parachute.

Consider a large cannonball and a small ping-pong ball, each being dropped from the same point on a tree. Which experiences the greater air resistance force as it falls?

- A) The ping-pong ball
- B) The cannonball
- C) The same on each

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Answer: B

Air resistance force is greater for greater speeds and for greater sizes. Cannonball has greater size, and also has greater speed. (Remember to distinguish b/n force and its effect -- acceleration)

See also detailed explanation in Lecture 3 questions about elephant vs feather, and iron ball vs wooden ball

A player catches a ball. Consider the action force to be the impact of the ball against the player's glove. The reaction to this force is

- a) player's grip on the glove
- b) Force the glove exerts on the ball
- c) Friction of ground against player's shoes
- d) Muscular effort in the player's arms
- e) None of these

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- d) Muscular effort in the player's arms
- e) None of these

Answer: b)

Force of object 1 on object 2 = -(Force of object 2 on object 1) – these two forces make action-reaction pair...

As a 1-kg ball falls, the action force is the 10-N pull of the Earth's mass on the ball. The reaction force is

- A) air resistance acting against the ball, but less than 10N
- B) acceleration of the ball
- C) pull of the ball's mass on the earth, but less than 10-N
- D) pull of the ball's mass on the earth, equal to 10-N
- E) None of these

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- D) pull of the ball's mass on the earth, equal to 10-N
- E) None of these

Answer: D

Every force can be thought of as part of an action-reaction pair: Force that object I exerts on object II is equal and opposite to the force that II exerts on I.

So here the reaction force is the gravitational pull on Earth exerted by the ball, and it is 10-N upwards.

A large heavy truck and a small baby carriage roll down a hill. Neglecting friction, at the bottom of the hill, the truck will have a greater

- A) speed.
- B) momentum.
- C) acceleration.
- D) all of these
- E) none of these

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- E) none of these

Answer: B

They'll have same acceleration and same speed (if they started with the same speed).
The truck will have more momentum as its mass is larger.

An automobile and a baby carriage traveling at the same speed collide head-on. The impact force is

- A) greater on the baby carriage.
- B) greater on the automobile.
- C) the same for both.

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c) The same for both – action/reaction
(Similarly, same momentum *change* for both)

Padded dashboards in cars are safer in an accident than nonpadded ones because an occupant hitting the dash has

- A) increased momentum.
- B) increased time of impact.
- C) decreased impulse.
- D) decreased time of impact.

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Answer: B, same change of momentum to final zero, but done over a longer time means the force is less.

A 2-kg chunk of putty moving at 2 m/s collides with and sticks to a 6-kg bowling ball initially at rest. The bowling ball and putty then move with a speed of

- a) 0
- b) 0.5 m/s
- c) 1 m/s
- d) 2 m/s
- e) More than 2 m/s

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b) Momentum before = momentum after

$$(2\text{kg})(2\text{m/s}) + 0 = ((2+6)\text{kg}) v$$

$$\text{So } v = 4/8 = 0.5 \text{ m/s}$$

Two cars of mass m are move at equal speeds v towards each other. What is their combined momentum after they meet?

- a) 0
- b) mv
- c) $2mv$
- d) None of these

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Answer a) Net momentum after = net mom. before = 0

Assuming they don't rebound from each other, how much of the kinetic energy was transformed to heat and sound?

All of it! i.e. mv^2

An astronaut, floating alone in outer space, throws a baseball. If the ball floats away at a speed of 20 meters per second, the astronaut will

- A) move in the opposite direction, but at a lower speed.
- B) move in the opposite direction but at a higher speed.
- C) move in the opposite direction at a speed of 20 m/s.
- D) not move as stated in any of the above choices.

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Answer: A

Momentum is conserved so the momentum gained by the ball is equal and opposite to the momentum gained by the astronaut. Since the astronaut has a larger mass than the ball, and momentum = mv , his/her speed will be less than that of the ball's.

If you throw a ball horizontally while standing on roller skates, you roll backward with a momentum that matches that of the ball. Will you roll backward if you go through the motions of throwing the ball but instead hold on to it?

A) Yes

B) No

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- A) Yes
- B) No

Answer: B

If no momentum is imparted to the ball, no oppositely directed momentum will be imparted to the thrower. Going through the motions of throwing has no net effect. If at the beginning of the throw you begin recoiling backward, at the end of the throw when you stop the motion of your arm and hold onto the ball, you stop moving too. Your position may change a little, but you end up at rest. No momentum given to the ball means no recoil momentum gained by you.

A ball rolling down an incline has its minimum kinetic energy

A) half way down the incline.

B) at the end the incline.

C) at the top of the incline.

D) impossible to predict without knowing the ball's mass

E) impossible to predict without knowing the size of the ball

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Answer: C) At top, it has max potential energy, and min kinetic energy. PE gets transformed to KE as it rolls, and speed increases.

Another Question:

Is there a point at which the ball rolling down the incline has equal potential and kinetic energy? If so, where is it?

Answer: Half-way down, since then the ball is at half its initial height so $PE = mgh$ is half as much, and by energy conservation, this half has gone into KE.

A 1000-kg car is hoisted up twice as high as a 2000-kg car is. Raising the more massive car requires

- A) Less work
- B) Twice as much work
- C) Four times as much work
- D) As much work
- E) More than four times as much work

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Answer: D. Work done = gain in potential energy = mgh .
So twice the mass with half the height, means the same potential energy.

A car moving at 100 km/hr skids 40 m with locked brakes. How far will the car skid with locked brakes if it were traveling at 50 km/hr?

- A) 5 m
- B) 10 m
- E) 20 m
- G) 40 m
- I) 80 m
- F) 160 m

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- A) 5 m
- B) 10 m
- E) 20 m
- G) 40 m
- I) 80 m
- F) 160 m

B)

At 50 km/h it has half the speed so $1/4$ times the KE..

Work done by brakes = $F \cdot d = \Delta KE$, so need $1/4$ times the distance, i.e. $1/4 \times 40 \text{ m} = 10 \text{ m}$.

A feather and a coin will have equal accelerations when falling in a vacuum because

- A) the force of gravity is the same for each in a vacuum.
- B) the force of gravity does not act in a vacuum.
- C) the ratio of each object's weight to its mass is the same.
- D) their velocities are the same.
- E) none of these.

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Answer: C)

This ratio is g = acceleration due to gravity

Which has greater kinetic energy, a person running at 4 mi/h or a dog of half the mass running at 8 mi/h?

- A) the dog
- B) the person
- C) Both have the same kinetic energy.
- D) More information is needed about the distance traveled.

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A) $KE = \frac{1}{2} mv^2$, so for dog, mass halved but v doubled means KE is doubled.

Suppose that your two friends are planning the design of a roller coaster. Friend “A” says that each summit must be lower than the previous one. Friend “B” disagrees and says that as long as the first one is the highest, then it doesn’t matter what height the others are. Who do you agree with?

- A) A
- B) B
- C) Neither of them – it doesn’t matter which summit is the highest

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- A) A
- B) B
- C) Neither of them – it doesn’t matter which summit is the highest

Answer: B

The height of the initial summit determines the total energy of the car at any point along the coaster. The car could just as well encounter a low summit before or after a higher one, so long as the higher one is enough lower than the initial summit to compensate for energy dissipation by friction.

A huge rotating cloud of particles in space gravitate together to form an increasingly dense ball. As it shrinks in size the cloud

- A) rotates slower.
- B) rotates faster.
- C) rotates at the same speed.
- D) cannot rotate.

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B) Ang mom is conserved, so if shrinks so that I decreases, then ang speed must increase

Consider a string with several rocks tied along its length at equally spaced intervals. You whirl the string overhead so that the rocks follow circular paths. Compared to a rock in the middle of the string, a rock at the outer end moves

- A) half as fast.
- B) twice as fast.
- C) at the same linear speed.

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Answer: B

They have the same angular (rotational) speed, but the one twice as far from the center has twice as large linear (tangential) speed.

A small boy places a rock under the middle of a of a long wood plank, sits near one end and his mother sits near the opposite end. To balance each other,

- A) both should move closer to the ends of the plank.
- B) the boy should move closer to his mother.
- C) the mother should move further away from the boy.
- D) both should move closer to the middle of the plank.
- E) None of the above choices would work.

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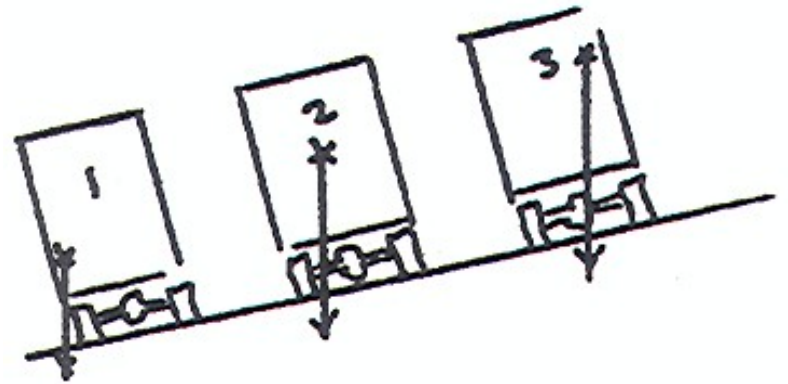
Answer: E

The mother has greater weight, so to balance the torque = $F \times \text{leverarm}$ of that of the boy's, the lever arm to the mother must be smaller, i.e. mother must move in closer (or boy move out further)

The centers of gravity of the three trucks parked on the hill are shown by the x's.

Which truck(s) will tip over?

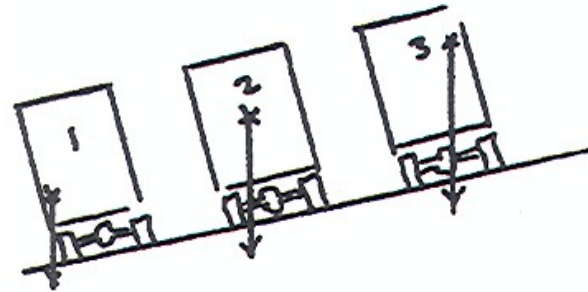
- A) 1
- B) 2
- C) 3
- D) 1 and 2
- E) 2 and 3
- F) 1 and 3
- G) None of them
- H) All of them



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Which truck(s) will tip over?

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- B) 2
- C) 3
- D) 1 and 2
- E) 2 and 3
- F) 1 and 3
- G) None of them
- H) All of them



Answer: A

As indicated. the center of gravity of Truck 1 is not above its support base, while that of trucks 2 and 3 are above theirs.

A solid ball and a hula-hoop, initially at rest, start rolling down a hill together. Which reaches the bottom first?

- A) The ball
- B) The hula-hoop
- C) It depends on their sizes and masses
- D) Both reach the bottom together

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Answer: A

A ball has least rotational inertia – more of its mass is closest to the axis of rotation. Doesn't depend on their sizes or masses – see lecture on this.

When doing somersaults, you'll more easily rotate when your body is

- A) straight with both arms at your sides.
- B) straight with both arms above your head.
- C) balled up.
- D) no difference

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- A) straight with both arms at your sides.
- B) straight with both arms above your head.
- C) balled up.
- D) no difference

C) Since want to decrease rotational inertia, pull in your mass close to your axis of rotation

Consider two stars orbiting each other. If the masses of both stars were doubled, then the force between them is

- A) Four times as much
- B) twice as much
- C) unaltered
- D) quarter as much
- D) None of these

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Answer: A, from $F = Gm_1m_2/d^2$

How about if the distance between them was also doubled?

Then, answer would be C, unaltered, (again, directly from F equation)

Consider three heavy objects A, B, and C, that are placed in a line. The mass of A is twice that of C. If B is placed exactly halfway between A and C, it will

- 1) accelerate toward A
- 2) accelerate toward C
- 3) Not accelerate at all
- 4) Oscillate between A and C

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Answer: 1

From the gravitational force law, $F = G \frac{M_1 M_2}{d^2}$

For the force on B due to A, put $M = \text{mass of A}$ above and for the force on B due to C, put $M = \text{mass of C}$ above.

Since d is the same for both cases (B is halfway between A and C), then the greater mass exerts the greater force, i.e. A. Gravitational force is always attractive, so B accelerates towards A.

Passengers in a high-flying jumbo jet feel their normal weight in flight, while passengers in an orbiting space-shuttle do not. This is because passengers in the space shuttle are

- A) Beyond the main pull of earth's gravity
- B) Above the earth's atmosphere
- C) Without support forces
- D) All of these
- E) None of these

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Answer: C

Note that Earth's gravitational force is significant on the space shuttle – this is what keeps it in orbit around us -- and likewise for the moon!

Another Qn: Why then doesn't the shuttle or moon come crashing into us?

Because they have tangential speed – the earth's gravity is what keeps them going in orbit rather than off in a straight line.

Which of these three produces the greatest tidal effect on *you* right now?

- A) the moon
- B) the sun
- C) the Earth

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- A) the moon
- B) the sun
- C) the Earth

Answer: C

Tidal effects are created by *differences* in the gravitational pull on different parts of an object that are different distances from the object that is exerting its gravitational force on it. These differences decrease for greater distances between the objects, because the gravitational force “flattens out”.

During an eclipse of the sun, the sun, moon and earth are in alignment, and the high ocean tides on earth are then

A) extra high

B) extra low

C) not particularly different than at any other time

During an eclipse of the sun, the sun, moon and earth are in alignment, and the high ocean tides on earth are then

- A) extra high
- B) extra low
- C) not particularly different than at any other time

A) Extra high because the tidal effects from the sun and tidal effects from the moon add up when sun, moon , and earth are in a line.