Review for Midterm 1

- Midterm 1 is Friday October 9
- On the seven chapters 2, 3, 4, 5, 6, 7, 8
- Bring No. 2 pencil for bubble-sheet and an eraser
- 45 multiple-choice questions

Resources for studying:

- go through all questions, exercises, and examples we did during lectures, homeworks and posted solutions
- with multiple-choice questions know confidently why the wrong answers are wrong
- revise "check yourself" questions in book
- additional questions in today's lecture
- email me if you have any questions

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 ($a = g$, speed gains/loses g m/s every second if falling/rising)
- Chapter 4: N's 2nd law, Fnet = 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 Fnet on system =0, collisions
- Chapter 7: Energy, Kinetic energy = $\frac{1}{2} m v^2$, Potential energy, Grav. PE = mgh, Work = $F\,d$, mechanical energy, change in mech. energy = 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 x lever arm, angular momentum = $I\,\omega$, ang mom conservation, CM/CG, stability

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

A) Because of Newton’s 1^{st} 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 1^{st} 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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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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B) equal to its weight divided by its mass.

C) zero.

D) equal to its weight

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.

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?

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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.

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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D) 9 m/s

C) Average speed =distance/time = 3m/0.5s = 6 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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A) velocity increases

B) acceleration increases.

C) both of these

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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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.

Answer d) Note, acc. in free-fall (on earth) is *always* $g \sim 10$ 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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a) 10 m/s
b) 20 m/s
c) 5 m/s
d) 0
e) None of these

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

What is it's acceleration at that time?

$a = g = 10\ m/s^2$ downwards, always for free-fall

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 since it loses 10m/s every second…

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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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

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

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.

So, if you're told an object thrown directly upwards from the ground spends 2s in the air before returning to ground (= it's "hang-time"), then you know the speed it was initially kicked up with was 10 m/s.

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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C) They have the same mass.
D) not enough information to say

A) Because weight =mg, and g least 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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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

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

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

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

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

What if there was a friction force of 5 N?

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

What horizontally-applied force will accelerate a 200-kg box at 1 m/s^2 across a floor against a friction force of 400N?

a) 200 N

b) 400 N

c) 600 N

d) 2400 N

e) None of these

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

C) Fnet = Fapplied – friction = ma

So, Fapplied = ma + friction = 200 + 400 = 600 N

Several balls of different masses are dropped from the 15th floor of the North Building. Neglecting air resistance, the quantity that has the same value for each ball

A) energy
B) acceleration
C) momentum
D) force exerted upon striking the ground
E) All of the above

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A) energy
B) acceleration
C) momentum
D) force exerted upon striking the ground
E) All of the above

Answer: B

In free-fall all objects fall at the same rate, $a = g$. The velocity will also be the same for all balls, but the momentum will not, since momentum $= mv$ and mass is different for each ball. Also their energies are different because their mass is different, and the force exerted upon striking the ground will also be different because of this.

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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b) Pull upward on the supporting strands to decrease the downward net force
c) Jump lightly
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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 btn 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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c) Friction of ground against player's shoes
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 wooden sphere and an iron sphere of the same size and shape are dropped simultaneously from a table and happen to reach the ground at the *same* time. The iron sphere has a greater

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

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C) speed.
D) all of these
E) none of these

Answer: A

If they're dropped at the same time and reach the ground at the same time, then they must have had the same speed and acceleration (air resistance was negligible or similar on both during the relatively short fall). The iron ball 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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B) greater on the automobile.
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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.

When two objects collide,

A) their total momentum is always conserved
B) their total energy is always conserved
C) their total energy and momentum are sometimes conserved
D) their total energy and momentum are always conserved unless heat is generated
E) more than one of the above is true
F) none of the above is true

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Answer: A
Energy is conserved only sometimes, when the collision is elastic.

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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e) More than 2 m/s

b) Momentum before = momentum after

(2kg)(2m/s) +0 = ((2+6)kg) v

So v=4/8 = 0.5 m/s

Newton’s Third Law is most closely related to

A) momentum conservation
B) angular momentum conservation
C) energy conservation
D) inertial resistance to changes in motion

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A) momentum conservation
B) angular momentum conservation
C) energy conservation
D) inertial resistance to changes in motion

Answer: A
Momentum conservation follows directly from Newton’s third law as explained directly in class lectures..

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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a) 0

b) mv

c) 2mv

d) None of these

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

And if they do bounce back, is it possible for them each to bounce back with a greater speed than their speed of approach? Why or why not?

No, because it would violate energy conservation,
Eg if they bounced back each with speed 2v, then although final momentum = 2mv – 2mv = 0 = initial momentum (so momentum conserved), the initial kinetic energy mv^2 is smaller than the final kinetic energy $\frac{1}{2} m (2v)^2 = 2mv^2$.

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

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

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
C) 20 m
D) 40 m
E) 80 m
F) 160 m

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A) 5 m
B) 10 m
C) 20 m
D) 40 m
E) 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.d = Δ KE, so need 1/4 times the distance, i.e. 1/4 x 40 m = 10 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

If several balls of different masses are thrown across a field with the same initial velocity, neglecting air resistance, the quantity that will have the same value for each ball is

A) momentum
B) energy
C) acceleration
D) impulse imparted upon striking the ground
E) all of the above

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A) momentum
B) energy
C) acceleration
D) impulse imparted upon striking the ground
E) all of the above

Answer: C
The acceleration is always just that due to gravity, 9.8 m/s^2, same for all objects when neglecting air resistance. Even though the velocity will be the same, the momentum will be different for each ball if the masses are different, and likewise the energy and impulse.

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 = ½ 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 where the cars initially start from rest. 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

Suppose that your two friends are planning the design of a roller coaster where the cars initially start from rest. 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

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.

If you haul up your bag of groceries up the stairs twice as fast as your friend hauls his equally-heavy bag of groceries, then

A) You have expended more energy in moving the bag up
B) You have exerted greater net impulse
C) You have exerted greater net force on the bag
D) You have exerted more power.

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C) You have exerted greater net force on the bag
D) You have exerted more power.

Answer: D

Power = Workdone/time. The work done on the bag is the change in its gravitational potential energy, mgh, which is the same for each bag, so there is the same work done, so you have expended same total energy in moving the bag up. (thinking of any sound, heat generated equally). But you do it in less time, so the power you exert is greater.

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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A) rotates slower.
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D) cannot rotate.

B) Angular momentum is conserved, so if shrinks so that moment of inertia I decreases, then angular speed ω 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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B) twice as fast.
C) at the same linear speed.

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 long wood plank, sits near one end and his heavier 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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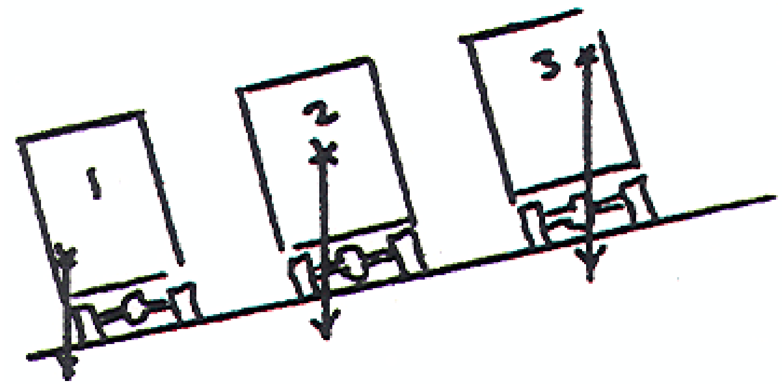
B) the boy should move closer to his mother.
C) the mother should move further away from the boy.
D) both should move closer to the middle of the plank.
E) None of the above choices would work.

Answer: E

The mother has greater weight, so to balance the torque = F x 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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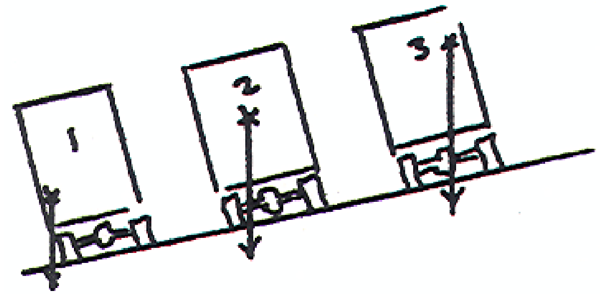

Which truck(s) will tip over?

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

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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C) It depends on their sizes and masses

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

If the polar icecaps melted, the resulting water would spread over the entire Earth. This new mass distribution would tend to make the length of a day

A) longer, because of the conservation of angular momentum.
B) longer, because of the conservation of rotational velocity.
C) stay the same, because of the conservation of angular momentum.
D) shorter, because of the conservation of angular momentum.
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Answer: A
More mass would be further away from the axis of rotation of the earth since it is moving away from the poles. So the rotational inertia of the earth would increase, causing a decrease in its angular velocity, i.e. a slower rotation, i.e a longer day.

When a twirling ice skater extends his arms outwards, his rotational speed

A) remains the same.
B) increases.
C) decreases.
D) becomes zero

When a twirling ice skater extends his arms outwards, his rotational speed

A) remains the same.
B) increases.
C) decreases.
D) becomes zero

Answer: C, decreases, since his rotational inertia increases when his arms are out (further away from axis of rotation), and since angular momentum is conserved, this means his rotational speed must decrease.