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Mechanics Basics

Exam — Mechanics

Pre-med/IB-style questions that build from Newton's laws and free-body diagrams to friction, tension, work–energy, momentum/impulse, circular motion, and torque—focused on conceptual reasoning and common traps.

75 items — Printable Exam

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1 Which of the following is a vector quantity?

A Energy

B Mass

C Time

D Force

E Temperature

2 A hockey puck slides on nearly frictionless ice after being struck. After the stick loses contact, which best describes the puck's motion?

A It must quickly come to rest because no force acts on it.

B It continues with constant velocity (same speed and direction).

C It speeds up because motion continues automatically.

D It moves in a circle because it has momentum.

E Its acceleration stays constant and positive.

3 Which property best measures an object's inertia?

A Weight

B Mass

C Speed

D Acceleration

E Volume

4 **A car moves in a straight line at constant speed on a level road. What can you conclude about the net force on the car?**

- A Net force is forward and large.
- B Net force is backward and large.
- C Net force is zero.
- D Net force must equal the car's weight.
- E Net force must be zero only if the car is not moving.

5 **A book rests on a horizontal table with no other interactions. Which forces act on the book?**

- A Weight downward and normal force upward
- B Weight downward and friction force upward
- C Normal force downward and weight upward
- D Weight downward, normal upward, and a "force of motion" forward
- E Only weight downward (because the table is not a force)

6 **Two identical forces act separately on two carts on a frictionless track. Cart X has mass m; cart Y has mass 2m. Compared with cart X, cart Y's acceleration is:**

- A Twice as large
- B The same
- C Half as large
- D Four times as large
- E Zero because it is heavier

7 **An astronaut travels from Earth to the Moon. Which statement is correct?**

A Her mass decreases because gravity is weaker.

B Her weight decreases but her mass stays the same.

C Her mass increases because the Moon has less air resistance.

D Her weight stays the same because she is the same person.

E Her mass and weight both become zero.

8 **Ignoring air resistance, two balls (one heavy, one light) are dropped from the same height at the same time. Which is true?**

A The heavier one hits first because it has more weight.

B The lighter one hits first because it has less inertia.

C They hit at the same time because they have the same acceleration g.

D They hit at the same time only if their masses are equal.

E Neither hits because gravity cancels inertia.

9 **A person stands on a scale inside an elevator moving upward at constant speed. Compared to standing still on the ground, the scale reading is:**

A Greater

B Smaller

C The same

D Zero

E Impossible to know without the elevator's mass

10 Which pair is a Newton's 3rd law action–reaction pair?

A Weight of a book and the normal force on the book

B Friction on a box and weight of the box

C Earth pulls the apple downward and the apple pulls Earth upward

D Tension in a rope and acceleration of the mass

E Normal force on the book and friction on the book

11 Why don't Newton's 3rd law force pairs cancel each other to give zero net force on a single object?

A Because action and reaction are not equal in magnitude.

B Because one of them is always friction.

C Because they act on different objects, not the same object.

D Because they happen at different times.

E Because net force depends on speed, not force.

12 A box is pushed to the right across a rough floor and is sliding. The friction force on the box points:

A To the right

B To the left

C Upward

D Downward

E Friction is zero because it is moving

13 A block rests on a horizontal table with no horizontal forces applied. The static friction force on the block is:

A μsN

B μkN

C Zero

D Equal to the weight mg

E Always nonzero to prevent motion

14 Which statement about static friction is correct?

A Static friction always equals μsN.

B Static friction adjusts from 0 up to a maximum value μsN.

C Static friction is always larger than kinetic friction for all materials.

D Static friction acts in the direction of motion.

E Static friction can only act upward.

15 For most dry surfaces, compared to kinetic friction, the maximum static friction is typically:

A Smaller

B Equal

C Larger

D Zero

E Negative

16 A block rests on an incline at angle (no other forces). The normal force on the block equals:

A mg

B mg sin

C mg cos

D mg tan

E 0

17 For the same incline (angle), the component of the weight parallel to the plane is:

A mg

B mg cos

C mg sin

D mg / sin

E mg / cos

18 **As the angle of an incline increases (0° → 90°), which trend is correct?**

- A mg sin decreases and mg cos increases
- B Both mg sin and mg cos increase
- C mg sin increases and mg cos decreases
- D Both mg sin and mg cos decrease
- E Both stay constant because mg is constant

19 **A box is pulled with a rope that makes an upward angle above the horizontal. Compared to pulling horizontally with the same rope tension, the friction force is usually:**

- A Larger, because the rope adds force
- B Smaller, because the upward component reduces the normal force
- C Unchanged, because friction is independent of normal force
- D Zero, because the rope lifts it completely
- E Impossible to compare without the rope length

20 **A mass hangs motionless from a light vertical string. The tension in the string is:**

- A Zero
- B Equal to mg
- C Greater than mg
- D Less than mg
- E Equal to m/g

21 Two masses hang on either side of a frictionless, massless pulley connected by a massless rope. Which statement about tension is correct?

A Tension is larger on the heavier side.

B Tension is smaller on the heavier side.

C Tension is the same in both vertical segments of the rope.

D Tension is zero because the rope is massless.

E Tension must equal the difference of the two weights.

22 In an Atwood machine, mass m1 is larger than mass m2. Neglecting friction and rope/pulley mass, which direction does the system accelerate?

A m1 accelerates upward and m2 downward

B m1 accelerates downward and m2 upward

C Both accelerate downward

D Both accelerate upward

E No acceleration occurs because forces cancel

23 In an ideal Atwood machine where m1 = m2, which statement is correct?

A The heavier side accelerates downward.

B Acceleration is zero; tension equals each weight.

C Acceleration is g because both are falling.

D Tension is zero because forces cancel.

E Tension equals the difference between weights.

24 Two blocks A and B push on each other on a frictionless surface and accelerate together. If you treat (A+B) as one combined system, the contact force between A and B is:

A A net external force on the system

B An internal force that cancels within the system

C The only force that can accelerate the system

D Equal to the system's total weight

E Zero because the surface is frictionless

25 A constant force acts on an object while it moves in the same direction as the force. The work done by this force is:

A Negative

B Zero

C Positive

D Always equal to the object's weight

E Always equal to the object's momentum

26 A force acts perpendicular to an object's displacement. The work done by this force is:

A Maximum and positive

B Maximum and negative

C Zero

D Equal to the object's kinetic energy

E Equal to the object's momentum

27 A hiker climbs to a vertical height h by two different paths: a steep direct path and a longer gentle path. Ignoring friction, the work done against gravity is:

A Greater on the longer path because the distance is longer

B Greater on the steep path because it feels harder

C The same for both paths because it depends only on height gained

D Zero on both paths because gravity is conservative

E Impossible to compare without the hiker's speed

28 If the speed of an object doubles, its kinetic energy becomes:

A Half as large

B Twice as large

C Four times as large

D Eight times as large

E Unchanged

29 **Which statement is the work–energy theorem?**

- A Net work equals the change in potential energy only
- B Net work equals the change in kinetic energy
- C Net work equals the momentum
- D Net work is always zero in motion
- E Net work equals mass times velocity

30 **Two students lift the same box through the same height. Student A lifts it slowly; Student B lifts it quickly. Ignoring losses, the work done by each is:**

- A A does more work because it takes longer
- B B does more work because it is faster
- C They do the same work, but B has greater power
- D A does more work because speed reduces gravity
- E Work must be zero because the box starts and ends at rest

31 **A ball is dropped from rest from a height h (ignore air). As it falls, which energy transformation occurs?**

- A Kinetic energy → gravitational potential energy
- B Gravitational potential energy → kinetic energy
- C Thermal energy → kinetic energy
- D Kinetic energy stays constant
- E Gravitational potential energy stays constant

32 **A block slides across a rough surface and slows down. Which statement is best?**

- A Mechanical energy is destroyed.
- B Mechanical energy is converted mainly into thermal energy due to friction.
- C Total energy is not conserved when friction acts.
- D Friction increases the block's kinetic energy.
- E Friction does positive work because it is a force.

33 **A spring is compressed by a distance x. If the compression is doubled to 2x, the elastic potential energy stored becomes:**

- A Half
- B Twice
- C Four times
- D Eight times
- E Unchanged

34 **An object falling through air reaches terminal velocity. At terminal velocity, which is true?**

- A Acceleration is maximum
- B Net force is zero and speed is constant
- C Weight is zero
- D Air resistance is zero
- E Gravity stops acting

35 **Which statement about momentum is correct?**

- A Momentum is a scalar and depends only on speed
- B Momentum is a vector and equals mass $\times$ velocity
- C Momentum is the same as kinetic energy
- D Momentum is conserved only in elastic collisions
- E Momentum has units of joules

36 **Momentum of a system is conserved when:**

- A There are no internal forces
- B The net external impulse on the system is zero
- C The collision is elastic
- D Objects have equal masses
- E Objects have equal speeds

37 **Impulse is best defined as:**

- A Force divided by time
- B Force multiplied by distance
- C Change in momentum
- D Change in kinetic energy
- E Mass multiplied by acceleration

38 Two different methods stop the same cart from the same initial speed to rest. Method 1 stops it in a short time; Method 2 stops it in a longer time. Which is correct?

- A Method 1 gives smaller average force
- B Method 2 gives smaller average force
- C Average force is the same because Δp is the same
- D Average force depends only on mass, not time
- E The cart cannot be stopped without changing momentum

39 In a perfectly inelastic collision (objects stick together), which statement is correct for an isolated system?

- A Momentum is not conserved
- B Kinetic energy is conserved
- C Momentum is conserved but kinetic energy decreases
- D Both momentum and kinetic energy increase
- E Both momentum and kinetic energy become zero

40 A gun fires a bullet. Immediately after firing, the gun moves backward (recoils). The best explanation is:

- A The bullet pulls the gun backward with a force larger than the gun's force on the bullet
- B Total momentum is conserved, so the gun gains opposite momentum to the bullet
- C The gun recoils because gravity pushes it backward

D The gun recoils because air pushes it backward

E Recoil happens only if the bullet is heavy

41 Torque about a pivot is largest when the applied force is:

A Applied close to the pivot and along the lever

B Applied far from the pivot and perpendicular to the lever arm

C Applied at the pivot

D Applied far from the pivot but parallel to the lever arm

E Applied with smaller force but any direction

42 A rigid body is in complete static equilibrium. Which must be true?

A Net force is zero only

B Net torque is zero only

C Both net force and net torque are zero

D Velocity must be zero

E Acceleration must be nonzero to maintain balance

43 Why is it easier to loosen a tight bolt using a longer wrench (applying the same force)?

A A longer wrench reduces friction in the bolt threads

B A longer wrench increases torque because the lever arm r is larger

C A longer wrench increases your mass, increasing force

D A longer wrench reduces the bolt's weight

E A longer wrench changes the bolt's material properties

44 Which design generally makes an object harder to tip over?

A Higher center of mass and narrow base

B Lower center of mass and wider base

C Higher center of mass and wider base

D Lower center of mass and narrow base

E Center of mass does not affect tipping

45 A tall box begins to topple when pushed. The box will start to tip (rather than just slide) when:

A The net force becomes zero

B The line of action of the weight passes outside the base of support

C The friction coefficient becomes negative

D The normal force becomes equal to the weight

E Its mass becomes smaller

46 **An object moves at constant speed in a circle. Which statement is correct?**

- A Net force is zero because speed is constant
- B There is a net force toward the center of the circle
- C Acceleration is zero because speed is constant
- D The net force points outward because the object wants to fly away
- E Gravity must be the centripetal force in all cases

47 **For uniform circular motion, if an object's speed doubles while the radius stays the same, the required centripetal force changes by a factor of:**

- A 2
- B 4
- C 1/2
- D 1/4
- E No change

48 **For uniform circular motion, if the radius doubles while speed stays the same, the centripetal acceleration becomes:**

- A Twice as large
- B Four times as large
- C Half as large
- D One quarter as large
- E Zero

49 A car turns on a flat (unbanked) road. What provides the centripetal force needed to follow the curve?

- A The car's weight
- B The normal force
- C Static friction between tires and road
- D A real outward "centrifugal force" from the road
- E The engine force always points inward

50 Why do seatbelts reduce injury in a collision (conceptually)?

- A They reduce the change in momentum to zero
- B They increase stopping time, reducing average force for the same change in momentum
- C They increase the car's mass, reducing acceleration
- D They remove friction, so you slide safely
- E They increase kinetic energy so the stop is smoother

51 Two masses attract gravitationally. If the distance between their centers doubles, the gravitational force becomes:

- A Twice as large
- B Four times as large
- C Half as large
- D One quarter as large
- E Zero

52 Compared to sea level, your weight at the top of a high mountain is slightly smaller mainly because:

- A Your mass is smaller at high altitude
- B The distance from Earth's center is larger, reducing gravitational force
- C Air pressure pushes you upward more
- D Your inertia decreases
- E Gravity reverses direction at high altitude

53 Astronauts in a circular orbit around Earth feel "weightless" mainly because:

- A There is no gravity in space
- B They are in continuous free fall with the spacecraft, so there is no normal force on them
- C Their mass becomes zero
- D Air resistance cancels gravity
- E Earth's gravity pushes them outward

54 A satellite moves in a higher circular orbit (larger radius) around Earth than another satellite. Ignoring atmosphere, its orbital speed is generally:

- A Larger because it has farther to travel
- B Smaller because the required centripetal acceleration is smaller at larger radius
- C The same because gravity is constant
- D Zero because it is weightless

E Impossible to compare without the satellite's mass

55 A ball moves to the right (+x) but is slowing down. Which statement about net force is correct?

A Net force is to the right because the ball is moving right

B Net force is zero because it is still moving

C Net force is to the left (−x)

D Net force must be upward

E Net force depends only on the ball's mass, not motion

56 A person stands on a scale in an elevator accelerating upward. Compared to mg, the scale reading (normal force) is:

A Greater than mg

B Equal to mg

C Less than mg

D Zero

E Negative

57 A person stands on a scale in an elevator accelerating downward (but not in free fall). Compared to mg, the scale reading is:

A Greater than mg

B Equal to mg

C Less than mg

D Exactly zero for any downward acceleration

E Negative if acceleration is downward

58 If an elevator cable snaps and the elevator falls freely (ignoring air), the scale reading for a person inside is approximately:

A mg

B 2mg

C 0

D Depends on the person's mass

E Negative

59 A horizontal force F is applied to a block on a rough horizontal surface. The block does NOT move. Which is correct about static friction (fs) if F is below the maximum static friction?

A fs = 0 always when there is no motion

B fs = F (opposite direction), so net force is zero

C fs = μsN always

D fs points in the same direction as F

E fs must be larger than F to prevent motion

60 **A block is sliding on a rough horizontal surface. You flip it to rest on a different face, changing the contact area but keeping the same mass and same materials. In the basic dry-friction model, the kinetic friction force is:**

- A Larger with larger contact area
- B Smaller with larger contact area
- C The same because $f_k = \mu_k N$ and N is the same
- D Zero because the surfaces are the same
- E Impossible to predict without the block's speed

61 **A constant horizontal pulling force is applied to a block sliding on a rough surface. If the block's mass is doubled (same surface, same μ_k, same applied force), the acceleration will most likely:**

- A Increase because mass increases friction
- B Stay the same because force is unchanged
- C Decrease because inertia increases and friction also increases
- D Become zero automatically
- E Reverse direction

62 **Two objects of different masses slide down the same frictionless incline from rest. Which statement is correct about their accelerations down the slope?**

- A Heavier object has larger acceleration
- B Lighter object has larger acceleration
- C They have the same acceleration down the slope
- D Acceleration depends on mass because weight depends on mass

E Acceleration is zero because there is no friction

63 In an ideal Atwood machine, suppose you add the same small mass to BOTH sides (so the difference between the two sides stays the same). What happens to the acceleration magnitude?

A It increases because the system is heavier

B It stays the same because the difference in weights is unchanged

C It decreases because the total mass (inertia) increases while the driving difference stays the same

D It becomes zero

E It reverses direction

64 In a collision between a large truck and a small car, during the impact the force exerted by the truck on the car is:

A Larger than the force the car exerts on the truck

B Smaller than the force the car exerts on the truck

C Equal in magnitude to the force the car exerts on the truck

D Zero because the truck is heavier

E Equal only if their masses are equal

65 A rocket accelerates forward in deep space by ejecting exhaust gas backward. This is possible because:

A Space provides air for the rocket to push on

B The rocket reduces its mass to zero

C Momentum is conserved: the exhaust gains backward momentum and the rocket gains forward momentum

D Gravity in space is always zero

E The rocket's thrust violates Newton's 3rd law

66 If the net work done on an object over an interval is zero, which statement must be true?

A The object must be at rest at the end

B The object's speed must be unchanged

C The object's velocity must be unchanged

D The object's displacement must be zero

E The net force must be zero at every moment

67 In uniform circular motion at constant speed, the centripetal force does no work on the object because:

A The force is zero

B The force is always perpendicular to the instantaneous displacement

C The object has no kinetic energy

D Work is not defined for circular motion

E Centripetal force is always friction

68 **A block slides on a rough surface over a distance d and stops. Which statement about friction's work is correct?**

- A Friction does positive work, increasing kinetic energy
- B Friction does negative work, reducing kinetic energy
- C Friction does zero work because it is a contact force
- D Friction does work equal to mgh
- E Friction does work only if the surface is inclined

69 **The same amount of work W is done on two objects, A and B, starting from rest. Object A has smaller mass than object B. Ignoring losses, which is correct about their final speeds?**

- A Both have the same final speed because the same work was done
- B The heavier object ends with greater speed
- C The lighter object ends with greater speed
- D Final speed depends only on force, not mass
- E Both remain at rest because work cannot change speed

70 **Two objects have the same momentum magnitude p, but different masses. Which object has larger kinetic energy?**

- A The one with larger mass
- B The one with smaller mass
- C They have the same kinetic energy
- D Kinetic energy depends only on direction, so cannot compare
- E Kinetic energy must be zero if momentum is the same

71 **Two objects have the same kinetic energy K, but different masses. Which object has larger momentum magnitude?**

- A The one with larger mass
- B The one with smaller mass
- C They have the same momentum
- D Momentum depends only on acceleration, so cannot compare
- E Momentum must be zero if kinetic energy is the same

72 **A firework explodes in midair. Just before the explosion, it is momentarily at rest. Neglecting external forces during the very short explosion, the total momentum of the fragments immediately after is:**

- A Zero (vector sum)
- B Equal to the total kinetic energy
- C Equal to the weight mg
- D Nonzero and pointing upward
- E Nonzero and pointing in the direction of the largest fragment

73 **Two identical balls collide head-on on a frictionless surface. Ball A moves toward stationary Ball B. The collision is perfectly elastic. Which outcome is correct?**

- A Both balls stop
- B Ball A stops and Ball B moves off with Ball A's original speed
- C Ball A rebounds with the same speed and Ball B stays still

D Both balls move forward, each with half the original speed

E They stick together and move with half the original speed

74 A car of mass m moving at speed v is brought to rest. If the stopping distance is doubled (same initial speed), the magnitude of the average stopping force is:

A Doubled

B Halved

C Unchanged

D Quadrupled

E Zero

75 Crumple zones in cars help reduce injuries mainly because they:

A Increase the change in momentum during a crash

B Decrease the stopping distance and time

C Increase stopping distance/time, reducing the average force needed to remove the same kinetic energy

D Make collisions perfectly elastic

E Eliminate friction during impact

#	Ans	Answer Text
	D	
2	B	It continues with constant velocity (same speed and direction).
	B	
4	C	Net force is zero.
	A	
6	C	Half as large
	B	
8	C	They hit at the same time because they have the same acceleration g.
	C	
10	C	Earth pulls the apple downward and the apple pulls Earth upward
	C	
12	B	To the left
	C	
14	B	Static friction adjusts from 0 up to a maximum value μsN.
	C	
16	C	mg cos
	C	
18	C	mg sin increases and mg cos decreases
	B	
20	B	Equal to mg
	C	
22	B	m1 accelerates downward and m2 upward
	B	
24	B	An internal force that cancels within the system
	C	
26	C	Zero
	C	
28	C	Four times as large
	B	
30	C	They do the same work, but B has greater power
	B	
32	B	Mechanical energy is converted mainly into thermal energy due to frictio…
	C	
34	B	Net force is zero and speed is constant
	B	
36	B	The net external impulse on the system is zero
	C	
38		Method 2 gives smaller average force