

1 mark for each correct answer. Total 15 marks. Each question also explains why every wrong option is wrong, so you can see which mistake each one tests.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	C	A	D	D	B	B	A	C	B	A	B	D	C	C

1. A book rests on a horizontal table. The weight of the book is the gravitational force of the Earth on the book. Which force forms a Newton's third law pair with the weight of the book?

A. The gravitational force of the book on the Earth

B. The normal force of the table on the book

C. The normal force of the book on the table

D. The normal force of the floor on the table

Answer: A · Newton's laws and lifts

A third-law pair acts on two different bodies and is the same type of force: the Earth pulls the book, so the book pulls the Earth.

B: This force is equal and opposite to the weight only because the book is in equilibrium. Both forces act on the same body, so they are not a third-law pair.

C: This is a contact force, not gravitational. It pairs with the normal force of the table on the book.

D: This force acts on the table and pairs with the push of the table on the floor.

2. A block rests on a rough horizontal floor. A small horizontal force F is applied to the block but it does not move.

- I. The frictional force on the block is equal to F .
- II. The frictional force on the block is equal to $\mu_s F_N$.
- III. The normal force on the block is equal to its weight.

Which statements are correct?

- A. I only
- B. I and II only
- C. I and III only
- D. II and III only

Answer: C · Friction

The block is in equilibrium: friction balances F (I), and the normal force balances the weight (III). Friction is less than its maximum value $\mu_s F_N$.

A: III is also correct: F is horizontal, so vertically only the weight and the normal force act, and they balance.

B: II is wrong: $\mu_s F_N$ is the largest possible static friction. Here friction only needs to balance the small force F .

D: II is wrong: the block is not about to slip, so the friction is less than $\mu_s F_N$. I is correct.

3. A box of mass m is pulled along a smooth horizontal floor by a rope. The tension in the rope is T and the rope makes an angle θ above the horizontal. The box stays on the floor. What is the acceleration of the box?

- A. $T \cos \theta / m$
- B. T / m
- C. $T \sin \theta / m$
- D. $(T \cos \theta - mg) / m$

Answer: A · Newton's laws and lifts

Only the horizontal component of the tension, $T \cos \theta$, accelerates the box along the floor. The vertical forces balance.

B: This uses the whole tension. Only the component along the floor causes the horizontal acceleration.

C: $T \sin \theta$ is the vertical component: it lifts the box a little and reduces the normal force.

D: The motion is horizontal and the weight acts vertically, so the weight is not in this equation. If the body moved vertically (for example, pushed up a wall), the weight would be in the equation.

4. Two solid spheres X and Y are held completely under water in the same tank. The radius of Y is twice the radius of X. The density of Y is half the density of X. What is (buoyancy force on Y) / (buoyancy force on X)?

- A. $1/2$
- B. 2
- C. 4
- D. 8

Answer: D · Buoyancy and drag

$F_b = \rho_{\text{water}} Vg$ depends only on the volume displaced. $V \propto r^3$, so doubling r gives $2^3 = 8$ times the buoyancy. The density of the sphere does not matter.

A: The density of the sphere does not affect the buoyancy.

B: This doubles the volume, but volume grows with r^3 .

C: This uses r^2 instead of r^3 .

5. A helium balloon of weight W rises vertically through still air at constant velocity. The buoyancy force on the balloon is F_b . What is the magnitude of the drag force on the balloon?

- A. W
- B. F_b
- C. $F_b + W$
- D. $F_b - W$

Answer: D · Buoyancy and drag

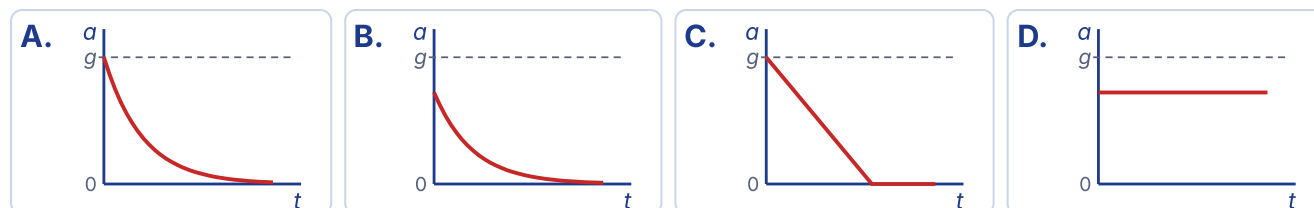
Constant velocity means zero net force. Up: F_b . Down: W and the drag (drag opposes the upward motion). So drag = $F_b - W$.

A: This would leave F_b unbalanced.

B: This would leave the weight unbalanced.

C: The drag acts downwards (against the upward velocity), together with the weight, so it cannot add to F_b .

6. A small steel ball is released from rest in a tall tube of oil. Which graph shows how the acceleration a of the ball varies with time t ?



- A. A
- B. B
- C. C
- D. D

Answer: B · Buoyancy and drag

At $t = 0$ the net force is $mg - F_b$, so a starts below g . The drag grows as the ball speeds up, so a falls smoothly towards zero (terminal speed).

A: At the start there is no drag, but the buoyancy of the oil already acts, so the starting acceleration is less than g .

C: The acceleration does not fall at a constant rate: it falls quickly at first and more slowly as it approaches zero.

D: The drag grows with speed, so the acceleration cannot stay constant.

7. A small sphere falls through a liquid with terminal speed v . A second sphere of the same material has half the radius. It falls through the same liquid. Stokes' law applies to both. What is the terminal speed of the second sphere?

- A. $v/8$
- B. $v/4$
- C. $v/2$
- D. $2v$

Answer: B · Buoyancy and drag

$v_t = 2r^2g(\rho_s - \rho_f)/9\eta$, so $v_t \propto r^2$. Halving r gives $(1/2)^2 = 1/4$ of the speed.

A: This uses r^3 , the change in weight, but the drag also changes with r .

C: This assumes $v_t \propto r$.

D: A smaller sphere falls more slowly, not faster.

8. A student of mass 50 kg stands on a scale in a lift. The lift has a downward acceleration of 2.0 m s^{-2} . What is the reading on the scale? ($g = 9.8 \text{ m s}^{-2}$)

- A. 390 N
- B. 490 N
- C. 590 N
- D. 100 N

Answer: A · Newton's laws and lifts

Down positive: $mg - F_N = ma \rightarrow F_N = m(g - a) = 50 \times (9.8 - 2.0) = 390 \text{ N}$.

B: This is the weight. It would be the reading only if the acceleration were zero.

C: This adds the acceleration. That is the reading for an upward acceleration.

D: This is ma only.

9. Block P (3.0 kg) is pulled by a horizontal force of 20 N. A light string joins P to block Q (1.0 kg). The frictional force on each block is 2.0 N. What is the tension in the string?



- A. 4.0 N
- B. 5.0 N
- C. 6.0 N
- D. 14 N

Answer: C · Connected bodies and pulleys

Whole system: $a = (20 - 2.0 - 2.0)/4.0 = 4.0 \text{ m s}^{-2}$. Block Q: $T - 2.0 = 1.0 \times 4.0 \rightarrow T = 6.0 \text{ N}$.

A: This is $m_Q a$ only. The string must also overcome the friction on Q.

B: This ignores friction: $a = 20/4.0 = 5.0 \text{ m s}^{-2}$ and $T = 1.0 \times 5.0$.

D: This is the net force on P ($20 - 6.0$), not the tension.

10. Two masses m and $3m$ hang from a light string that passes over a smooth, fixed pulley. The masses are released from rest. What is the magnitude of the acceleration of the masses?

- A. $g/4$
- B. $g/2$
- C. $2g/3$
- D. g

Answer: B · Connected bodies and pulleys

$$a = (M - m)g / (M + m) = (3m - m)g / 4m = g/2.$$

A: This divides the weight of the small mass by the total mass.

C: This divides by $3m$ instead of the total mass $4m$.

D: Each mass is held back by the tension, so $a < g$.

11. A block of mass 2.0 kg on a smooth horizontal table is joined by a light string over a smooth pulley to a hanging mass of 0.50 kg . What is the acceleration of the block? ($g = 9.8 \text{ m s}^{-2}$)

- A. 2.0 m s^{-2}
- B. 2.5 m s^{-2}
- C. 4.9 m s^{-2}
- D. 9.8 m s^{-2}

Answer: A · Connected bodies and pulleys

The only unbalanced force on the system is the weight of the hanging mass: $a = mg / (M + m) = 0.50 \times 9.8 / 2.5 = 1.96 \text{ m s}^{-2} \approx 2.0 \text{ m s}^{-2}$.

B: This divides by 2.0 kg only. The hanging mass must also be accelerated.

C: This is $0.50 \times 9.8 \div 1.0$, which has no meaning here.

D: The hanging mass is not in free fall: the string pulls it up.

12. A block slides down a rough slope at constant speed. The slope makes an angle θ with the horizontal. The mass of the block is m .

- I. The resultant force on the block is zero.
- II. The frictional force on the block is $mg \sin \theta$.
- III. The coefficient of dynamic friction is $\cos \theta$.

Which statements are correct?

- A. I only
- B. I and II only
- C. II and III only
- D. I, II and III

Answer: B · Slopes

Constant speed means zero resultant force (I). Along the slope friction = $mg \sin \theta$ (II). Then $\mu_d mg \cos \theta = mg \sin \theta$, so $\mu_d = \tan \theta$, not $\cos \theta$.

A: II is also correct: along the slope, friction must balance $mg \sin \theta$.

C: I is correct (constant velocity). III is wrong: $\mu_d = \tan \theta$.

D: III is wrong: $\mu_d = \tan \theta$.

13. A box rests on the floor of a lift. The lift is moving upwards and slowing down. Which row is correct?

Direction of the acceleration of the box	Normal force on the box compared with its weight
A. upwards	greater
B. upwards	less
C. downwards	greater
D. downwards	less

- A. A
- B. B
- C. C
- D. D

Answer: D · Newton's laws and lifts

Slowing down while moving up $\rightarrow$ acceleration downwards. The resultant force is downwards, so $F_N < mg$.

A: The lift is slowing down while moving up, so the acceleration is opposite to the velocity: downwards.

B: The acceleration is downwards. And an upward acceleration would need $F_N > mg$.

C: A downward acceleration needs a downward resultant force, so F_N must be less than mg .

14. A block of mass 1.0 kg rests on top of a block of mass 3.0 kg. The lower block is on a smooth horizontal floor. The coefficient of static friction between the blocks is 0.40. A horizontal force F is applied to the lower block. What is the largest F for which the blocks move together? ($g = 9.8 \text{ m s}^{-2}$)

- A. 3.9 N
- B. 12 N
- C. 16 N
- D. 39 N

Answer: C · Connected bodies and pulleys

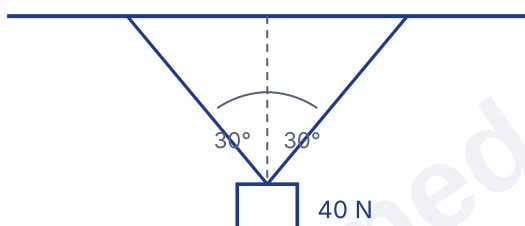
Largest friction on the top block = $0.40 \times 1.0 \times 9.8 = 3.92 \text{ N}$, so its largest acceleration is 3.92 m s^{-2} .
Together: $F = 4.0 \times 3.92 = 15.7 \text{ N} \approx 16 \text{ N}$.

A: This is the largest friction force on the top block, not the force on the whole system.

B: This accelerates only the 3.0 kg block: $3.0 \times 3.92 \text{ N}$.

D: This leaves out the coefficient of friction: 4.0×9.8 .

15. A lamp of weight 40 N hangs at rest from two strings. Each string makes an angle of 30° with the vertical. What is the tension in each string?



- A. 17 N
- B. 20 N
- C. 23 N
- D. 40 N

Answer: C · Equilibrium

Vertically: $2T \cos 30^\circ = 40 \rightarrow T = 40 / (2 \times 0.866) = 23 \text{ N}$.

A: This multiplies by $\cos 30^\circ$ instead of dividing.

B: This shares the weight equally but ignores the angle: the strings are not vertical.

D: This uses $\sin 30^\circ = 0.5$ instead of $\cos 30^\circ$: the angle is measured from the vertical.