

MODULE 14

DIGGING DEEPER EXERCISE 2

This Digging Deeper exercise is designed to strengthen your understanding of Newton's laws by applying them in slightly more challenging and realistic situations. The aim is not simply to obtain correct answers, but to sharpen your ability to analyse forces, interpret motion carefully, and think like a physicist. Work through the questions thoughtfully, and remember that **complete answers are provided at the end of the exercises** so you can check your progress and build confidence as your understanding grows.

EXERCISE 2A: BINDER QUESTIONS

Question 1

A body is observed to move in a straight line with constant velocity for several seconds. Explain what must be true about the vector sum of forces during this interval, and why this conclusion does not depend on the magnitude of the velocity.

Question 2

Two bodies move along the same straight line:

Body A is at rest.

Body B moves with constant velocity 8m/s.

Explain why physics imposes the same force-condition on both situations, even though one involves motion and the other does not.

Question 3

Everyday experience suggests “motion needs force.” Identify precisely which physical quantity actually needs a resultant force to change, and explain why the everyday statement seems true on Earth.

Question 4

Give a careful explanation of why “no force acts” and “resultant force is zero” are not the same statement, and explain which one matches real motion on Earth more often.

Question 5

A student says: “*Since Newton’s third law suggests that forces come in equal and opposite pairs, acceleration should be impossible.*” Explain the exact error in this reasoning without using any numerical example.

Question 6

Two students push each other on a smooth surface and move apart. Without using action–reaction language as a shortcut, explain why both can accelerate even though they interact with equal and opposite forces.

Question 7

A body moves upward while slowing down. Many learners say “*the acceleration is upward because it is moving upward.*” Explain why that statement is wrong and how to decide the acceleration direction correctly.

Question 8

A student insists that “*heavier objects always fall faster because they have larger weight.*” Explain the missing idea that repairs the argument and show how Newton’s second-law thinking resolves the confusion.

Question 9

On a rough horizontal surface, a box is pushed and moves at constant speed. Explain what this implies about the horizontal forces, and why this does not imply that friction is absent.

Question 10

A student treats the normal reaction as an “automatic equal and opposite” force to weight. Explain why this is not generally correct and describe one condition that must be true for $N = mg$ to hold.

Question 11

Two objects collide and exert forces on each other for the same time interval. Explain how they can experience equal and opposite forces yet undergo different accelerations and different changes in velocity.

Question 12

In a braking event, explain why increasing stopping time reduces injury risk, and identify which Newton-law idea links force size to how rapidly velocity changes.

EXERCISE 2A: REAL QUESTIONS**Question 13**

Kipute is standing in a daladala. The driver brakes suddenly and she lurches forward even though nobody pushes her. Explain this observation.

Question 14

Kipanga rides a bicycle on a straight road. When he stops pedalling, the bicycle does not stop immediately but gradually slows down. Explain what this reveals about the forces acting during the motion.

Question 15

Mr. Akilikubwa places a phone on the dashboard of a moving car. When the car accelerates forward, the phone sometimes slides backward. Explain why the phone does not always move together with the car.

Question 16

Kipute pushes a heavy desk across a classroom floor. At first it does not move, then it suddenly starts moving. Explain why the behaviour changes.

Question 17

A bag of cement is loaded in the back of a pickup. When the pickup speeds up, the bag tends to slide backward relative to the vehicle. Explain why this relative motion occurs.

Question 18

Kipute is inside a lift. As the lift starts moving upward, she feels heavier for a moment. As it slows down near the top, she feels lighter. Explain these sensations.

Question 19

A bodaboda rider carries a passenger and tries to accelerate away from rest. Compared with riding alone, the motorcycle picks up speed more slowly. Explain why.

Question 20

A student jumps down from a low platform and bends their knees deeply on landing. Explain why this reduces the risk of injury.

Question 21

A book rests on a table. Kipanga says: “*Because the book is not moving, there are no forces acting on it.*” Explain why this statement is incorrect.

Question 22

Kipanga rides a bicycle through a muddy path and then on a smooth tarmac road. He notices that the same pedalling effort gives different accelerations. Explain this difference.

Question 23

A bodaboda suddenly stops but the passenger may fall if not holding tightly. Explain this effect.

Question 24

Two identical plastic bottles are pushed along the floor with the same initial speed. One is empty and one is filled with sand. The filled bottle travels a shorter distance before stopping. Explain why this happens in real conditions.

Question 25

A car hits a pothole and passengers feel a sudden upward jolt. Explain why the forces on the passengers change suddenly.

EXERCISE 2C: HOT QUESTIONS**Question 26**

A lift moves vertically. At a certain instant, the lift is moving upward but slowing down at 2.0m/s^2 . A passenger of mass 70kg stands on a scale.

- (a) Determine the scale reading at that instant.
- (b) State whether the passenger feels heavier, lighter, or normal, and justify using the result.

(Take $g=9.8\text{m/s}^2$)

Question 27

A block of mass 5.0kg rests on a rough horizontal surface. The coefficient of static friction is 0.40 and the coefficient of kinetic friction is 0.30.

A horizontal force P is applied and gradually increased.

- (a) Determine the maximum value of P for which the block remains at rest.
- (b) Immediately after the block just begins to move, determine its acceleration if P remains unchanged.

(Take $g=9.8\text{m/s}^2$)

Question 28

A car of mass 1000kg travels on a straight horizontal road at 25m/s. The driver applies the brakes, producing a constant braking force of magnitude F. The car comes to rest in 100m.

- (a) Determine F.
- (b) Determine the stopping time.
- (c) State whether increasing the mass of the car (with the same braking force) would increase, decrease, or leave unchanged the stopping distance. Explain.

Question 29

Kipute and Kipanga stand on frictionless ice facing each other. Kipute has mass 50kg and Kipanga has mass 75kg. They push each other apart and Kipute moves away at 4m/s.

- (a) Determine Kipanga's speed immediately after the push.
- (b) Determine the ratio of their accelerations during the push.

Question 30

A ball of mass 0.20kg strikes a wall normally with speed 6.0m/s and rebounds with speed 4.0m/s. The contact time with the wall is 0.020s.

- (a) Determine the average force exerted by the wall on the ball.
- (b) State the direction of this force clearly.

ANSWERS TO DIGGING DEEPER EXERCISE 2**EXERCISE 2A**

1. Since the velocity is constant, acceleration is zero. By Newton's first law, a body with zero acceleration must have zero resultant force. This conclusion depends only on the absence of velocity change because acceleration measures change of velocity, not its magnitude.
2. In both cases the acceleration is zero. By Newton's first law, zero acceleration requires zero resultant force whether the velocity is zero (rest) or a non-zero constant value.
3. A resultant force is required to change velocity, not to maintain it. By Newton's second law, the net force is proportional to acceleration, not velocity.

The everyday idea seems true because presence of resistive forces on Earth oppose motion, so an applied force is needed to balance them.

4. "No force acts" means the body is completely isolated. "Resultant force is zero" means forces act but cancel.

Real motion on Earth usually involves balanced forces, not absence of forces because there is always interaction between bodies.

5. The error is assuming action–reaction forces act on the same body. By Newton's third law, action–reaction forces act on different bodies and therefore cannot cancel to prevent acceleration of a single body.
6. Each student experiences a force due to interaction with the other. **Because their masses may differ**, the same force produces different accelerations according to $a = F/m$.
7. Acceleration depends on the direction of the resultant force, not on the direction of motion (velocity direction).

Slowing down while moving upward means acceleration is downward.

8. Although heavier objects have larger weight (W), they also have proportionally larger mass. By Newton's Second Law, $a = W/m$, so gravitational acceleration is independent of mass when resistive forces are negligible.
9. Constant speed implies zero acceleration which in turn means zero resultant force in accordance with Newton's first law.

This implies that the applied force balances friction exactly; so friction is present, not absent.

10. The normal reaction can differ from weight if there are vertical components of other forces or vertical acceleration. $N = mg$ only when acceleration perpendicular to the surface is zero and no other perpendicular forces act.

11. By Newton's third law, forces during collision are equal and opposite. By Newton's second law, different masses experience different accelerations, leading to different velocity changes over the same time interval.

12. Increasing stopping time reduces acceleration. By Newton's second law, smaller acceleration produces smaller force, reducing injury risk during braking.

EXERCISE 2B

13. Kipute's body continues with its forward velocity because of inertia. By Newton's first law, her motion will not change unless a resultant force acts on her. When the daladala brakes, her feet are slowed by contact with the floor, but her upper body tends to keep moving forward briefly, so she lurches forward relative to the vehicle.

14. When Kipanga stops pedalling, the bicycle is no longer receiving a driving force, but it keeps moving due to inertia. It slows down because there is a backward resultant force due to resistive forces such as air resistance and friction. By Newton's second law, a backward resultant force produces a backward acceleration, so the speed decreases gradually.

15. For the phone to move with the car, a forward frictional force must act on the phone to give it the same acceleration as the dashboard. If the friction available is not large enough, the phone cannot gain the car's acceleration, so it slips and appears to move backward relative to the accelerating car.

16. Before the desk moves, static friction adjusts to match the applied push, keeping the resultant force zero so the desk stays at rest, consistent with Newton's first law. When the push becomes large enough to exceed the maximum possible static friction, the desk starts moving. Once it is moving, friction becomes kinetic friction, which is usually smaller than the maximum static friction, so motion becomes easier to maintain.

17. When the pickup accelerates forward, the bag tends to maintain its original state of motion due to inertia. If friction between the bag and the pickup bed is not sufficient to provide the needed forward acceleration to the bag, the bag accelerates less than the pickup and therefore slides backward relative to the vehicle.

18. Feeling heavier means that the normal reaction on Kipute is greater than her weight, while feeling lighter means that the normal reaction is smaller than her weight. When the lift accelerates upward, Kipute must have an upward resultant force, so by Newton's second law the normal reaction must be greater than her weight. When the lift accelerates downward, the resultant force is downward, so the normal reaction is less than her weight.

19. Carrying a passenger increases the total mass of the system being accelerated. If the driving force is roughly unchanged, Newton's second law shows that a larger mass experiences a smaller acceleration, so the motorcycle speeds up more slowly.

20. Bending the knees increases the time over which momentum is reduced to zero. For the same change in momentum, Newton's second law shows that increasing stopping time reduces the average force, lowering injury risk.

21. The book is at rest, so its acceleration is zero and the resultant force is zero. The forces acting are its weight downward and the normal reaction upward, which balance. Therefore, the book is not force-free; it is in equilibrium because forces act and cancel, not because no forces act.

22. On muddy ground, resistive forces are larger, reducing the resultant forward force. On smooth tarmac, resistive forces are smaller, so the same driving effort produces a larger acceleration according to Newton's second law.

23. When the bodaboda stops suddenly, the passenger tends to continue moving forward due to inertia. A backward resultant force from contact with the seat or rider is required to stop the passenger safely.

24. Although the filled bottle has greater inertia, its larger weight increases the normal reaction and hence friction. The larger resistive force produces a larger deceleration, allowing it to stop sooner in real conditions.

25. When the car hits a pothole, the vertical motion of the car changes very rapidly. This produces a sudden change in the passengers' acceleration. By Newton's second law, a sudden change in acceleration requires a sudden change in the resultant force, so the normal reaction on the passengers increases sharply for a short time, producing the strong upward jolt.

EXERCISE 2C

26. (a) 546N (b) The passenger feels lighter. **Justification:** This is because although the lift is moving upward, it is slowing down, so the acceleration (and hence the resultant force) is downward. This makes the normal reaction smaller than the passenger's weight.

27. (a) 19.6N (b) 1.96m/s

28. (a) 3125N (b) 8.0s (c) Stopping distance increases. **Explanation:** With the same braking force, increasing the mass reduces the deceleration of the car according to Newton's second law. Since the car still has to reduce its speed from the same initial value to zero, a smaller deceleration means the car takes longer and travels a greater distance before stopping.

29. (a) 2.67m/s (b) 3:2

30. (a) 100N (b) Opposite to initial motion