Newton's Three Laws of Motion

N1: An object continues its state of rest or move with constant velocity unless a resultant force acts on it.

If the forces on the object are balanced, the object is in equilibrium

- Resultant force is zero
- No change in object's motion.
  - If it was at rest, it remains at rest.
  - If it was moving with constant velocity, it will continue to move with same velocity.

If the forces acting on the object are not balanced

- There is a resultant force.
- There is a change in the object's motion
  - objects speed might increase
  - objects speed might decrease
  - objects direction might change

N2: It is a continuation of the first law. It explains what happens when a resultant force acts on the object (or when forces are not balanced).

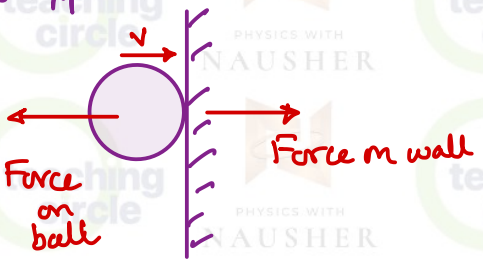
It gives the definition of resultant force.

Force is the rate of change of momentum.

$$F = \frac{\Delta p}{t} \implies F = ma$$

F: net/resultant force (N)
m: mass (kg)
a: acceleration (ms^{-2})

N3: Whenever 2 bodies interact, the forces exerted are equal in magnitude and opposite.



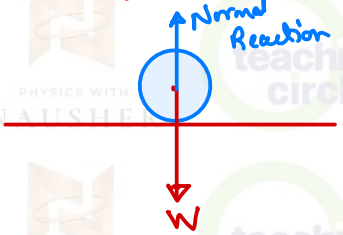
$$\text{Force on ball} = -\text{Force on wall.}$$

Conditions for N3 Law

A N3 law force pair must:

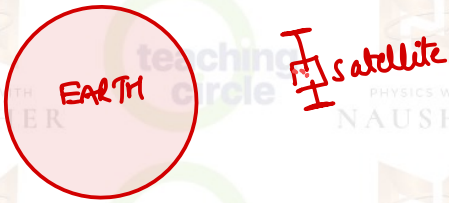
- have same magnitude
- be opposite in direction
- act on 2 different objects
- must be of same type.

Q. Is this a N3 law pair?



Q. Draw N3 law pair

a)



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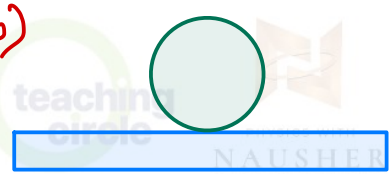
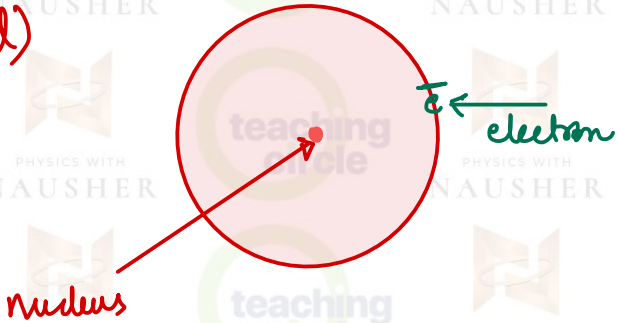


c)

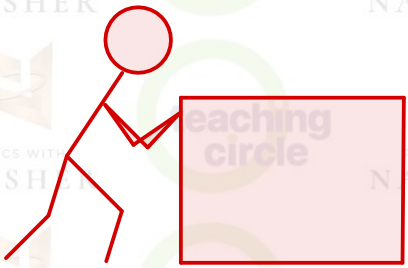
d)



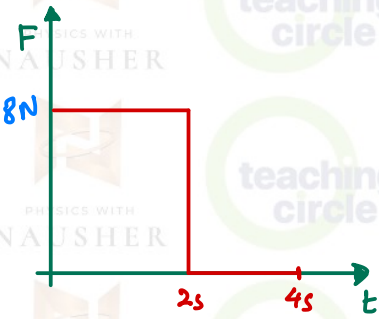
e)

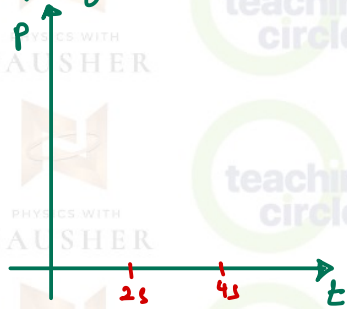
f)

g)

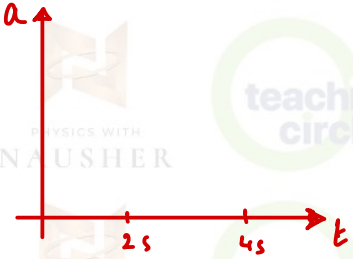


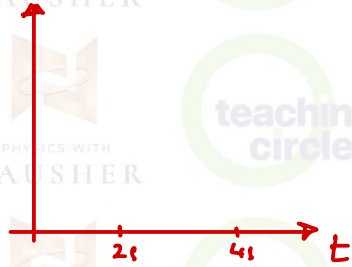
Q. An object is initially at rest. A force F acts on it. The force varies with time as shown. Sketch p-t graph for first 4s.



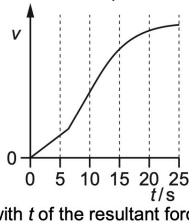


ii) Mass of the object is 2kg. Sketch



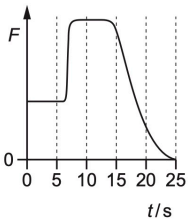


17 A bus takes a time of 25 s to reach a constant speed while travelling in a straight line. A graph of speed v against time t is shown.

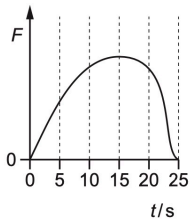


Which graph shows the variation with t of the resultant force F on the bus?

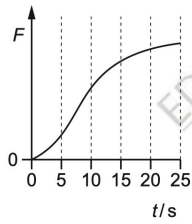
A



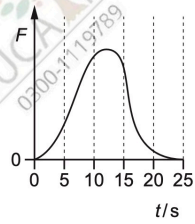
B



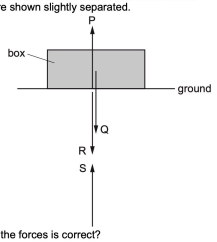
C



D



A box is shown resting on the ground. Newton's third law implies that four forces of equal magnitude are involved. These forces are labelled P, Q, R and S.
Forces P and Q act on the box. Forces R and S act on the Earth.
For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

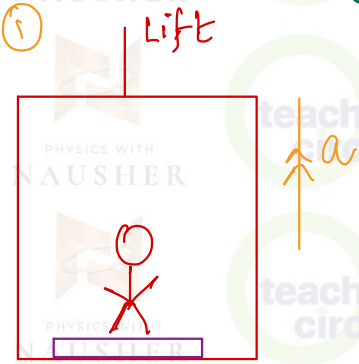
A P is the equal and opposite force to Q and both are forces of contact.
B Q is the equal and opposite force to P and both are gravitational forces.
C R is the equal and opposite force to S and both are forces of contact.
D S is the equal and opposite force to Q and both are gravitational forces.

A firework rocket is fired vertically upwards. The fuel burns and produces a constant upwards force on the rocket. After 5 seconds there is no fuel left. Air resistance is negligible.
What is the acceleration before and after 5 seconds?

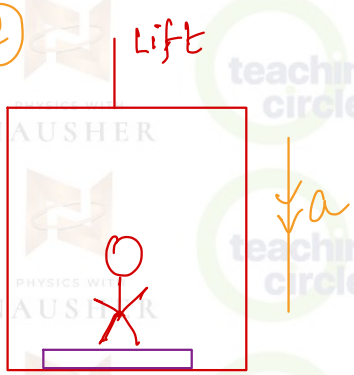
	before 5 seconds	after 5 seconds
A	constant	constant
B	constant	zero
C	increasing	constant
D	increasing	zero

An object accelerating upwards, downwards and free fall.

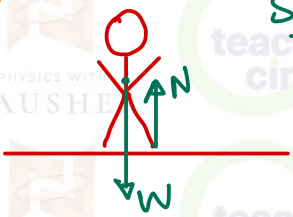
(1)



(2)



(3)



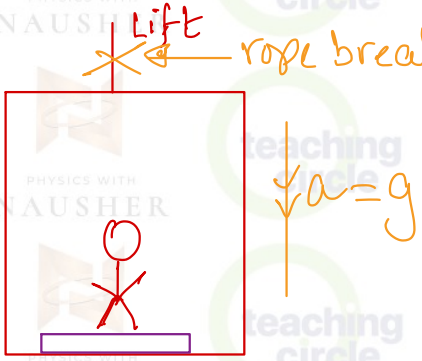
Standing on ground

$W = mg$

N balances weight

$F_R = N - W = 0$

$N = W$



Freefall

$F - f = ma$

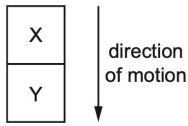
$W - N = mg$

Normal Reaction = 0

Weightlessness

- the resultant force the object feels is zero because everything around it is falling at the same rate.
- Key concept: It is due to relative motion being zero.

Two blocks X and Y are falling through a vacuum in a uniform gravitational field, as shown.



Block X has weight $2w$.

Block Y has weight w.

The blocks do not move apart.

Which value best represents the force exerted by block X on block Y?

A 0 **B** w **C** $1.5w$ **D** $2w$

An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

What is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

A $1.2mg$ **B** mg **C** $0.8mg$ **D** 0

(a) State Newton's second law of motion.

.....

.....[1]

(b) A car of mass 850 kg tows a trailer in a straight line along a horizontal road, as shown in Fig. 2.1.

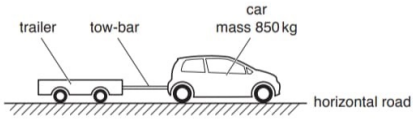


Fig. 2.1

The car and the trailer are connected by a horizontal tow-bar.

The variation with time t of the velocity v of the car for a part of its journey is shown in Fig. 2.2.

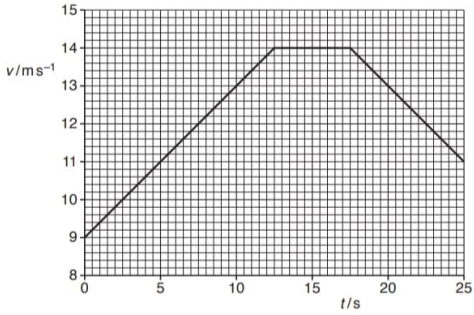


Fig. 2.2

(i) Calculate the distance travelled by the car from time $t = 0$ to $t = 10$ s.

distance = ... m [2]

(ii) At time $t = 10$ s, the resistive force acting on the car due to air resistance and friction is 510 N. The tension in the tow-bar is 440 N.

For the car at time $t = 10$ s:

1. use Fig. 2.2 to calculate the acceleration

acceleration = ... $m s^{-2}$ [2]

2. use your answer to calculate the resultant force acting on the car

resultant force = ... N [1]

3. show that a horizontal force of 1300 N is exerted on the car by its engine

[1]

4. determine the useful output power of the engine.

output power = ... W [2]