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CANDIDATE NAME	
CANDIDATE CLASS	

PHYSICS **0625/11**

Form 2

HOMEWORK

INSTRUCTIONS

- Print out all the notes and bring the printed copy on opening day
- Answer all questions in your exercise book

TOPIC 3 Dynamics

Objectives

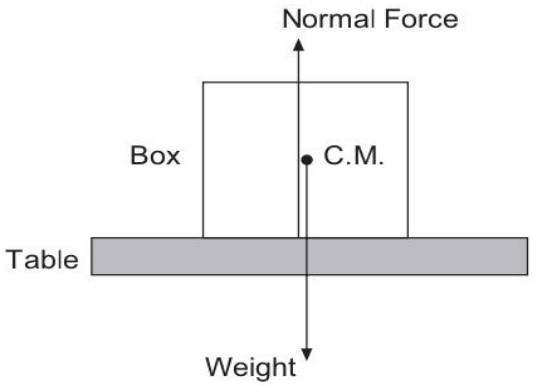
Candidates should be able to:

(a) apply Newton's Laws to:
(i) describe the effect of balanced and unbalanced forces on a body
(ii) describe the ways in which a force may change the motion of a body
(iii) identify action-reaction pairs acting on two interacting bodies (stating of Newton's Laws is not required)
(b) identify forces acting on an object and draw free body diagram(s) representing the forces acting on the object (for cases involving forces acting in at most 2 dimensions)
(c) solve problems for a static point mass under the action of 3 forces for 2-dimensional cases (a graphical method would suffice)
(d) recall and apply the relationship *resultant force* = *mass* × *acceleration* to new situations or to solve related problems
(e) explain the effects of friction on the motion of a body

NOTES.....

3.1 Forces

1. A force (SI unit: Newton, symbol: N) is a push or a pull exerted on a body by another body, i.e. an object resting on a table will have a contact force (normal force) acting on it upwards. This force is equal to its weight.



Note:
1. The Normal Force and Weight arrows are of the same length but in opposite directions.
2. Normal Force arrow starts from the base of box (contact between the box and the table top).
3. Weight starts from the centre of mass of the box, C.M. (indicated by the black dot).

2. Effects of a force on a body:
   (a) Increase/ decrease speed of a body (accelerate/ decelerate)
   (b) Change direction of a moving body

3. Newton's First Law:
   A body will remain stationary or in continuous linear motion unless acted upon by a resultant force.

4. Newton's Second Law:
   Resultant vector sum of forces on body is given by:

$$F = ma$$

   where m is the mass of the body and a is the acceleration of the body in the direction of F.

5. Newton's Third Law:
   For every action, there is an equal and opposite reaction.

3.2 Balanced and Unbalanced Forces

1. Balanced forces: If resultant $F = 0$ N, the body is either stationary or moving with constant velocity.

   Example 3.1
   A parachutist falls to the ground at terminal velocity when his weight is equal to the upward force acting on him due to air resistance. Hence, the resultant force acting on him is zero, i.e. his acceleration is zero.

2. Unbalanced forces: If resultant $F \neq 0$ N,
   (a) a stationary body will start moving,
   (b) a moving body will change its velocity.

3.3 Friction

1. Friction is the force which opposes motion when objects slide over each other. For a moving object, the friction on the object acts in the direction opposite to its motion.

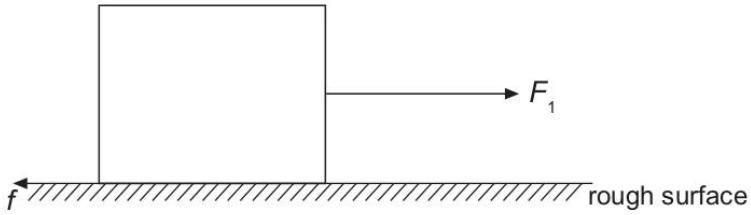
2. Advantages of friction:
   (a) Walking on roads.
   (b) Friction in brake pads and wheels of cars and bicycles.

3. Disadvantages of friction:
   (a) Wears down moving parts of machines.
   (b) For an object moving on a rough surface, more energy is needed to move the object as compared to moving on a smooth surface.
   (c) For an object moving on a rough surface, energy is required for the object to maintain a constant speed. Otherwise, it will slow down and come to a stop.

4. Ways to overcome friction:
   (a) Use lubricant (i.e. graphite or oil) for moving parts of machines.
   (b) Use ball-bearings between moving surfaces.
   (c) Make sure moving parts of machines have very smooth surfaces.

Example 3.2

An object weighing 50 N lies on a rough surface. A constant F_1 force of 12 N acts on the object. The frictional force f acting on the object is 2 N. Find the acceleration of the object. (Take acceleration due to gravity to be 10 m/s^2.)



Solution

Vertically, resultant force = normal force – weight = 0 N

Horizontally, resultant force $R = F_1 - f = 12 - 2 = 10$ N

(Object will only accelerate on horizontal plane)

Mass of object = $\frac{50}{10}$ kg

= 5 kg

Using formula:

$F = ma$

$10 = 5a$

$a = 2$ m/s^2

(Object is accelerating at 2 m/s^2 to the right, i.e. in the direction of F.)

Example 3.3

An object moves in a circular path at a constant speed. Is the object accelerating?

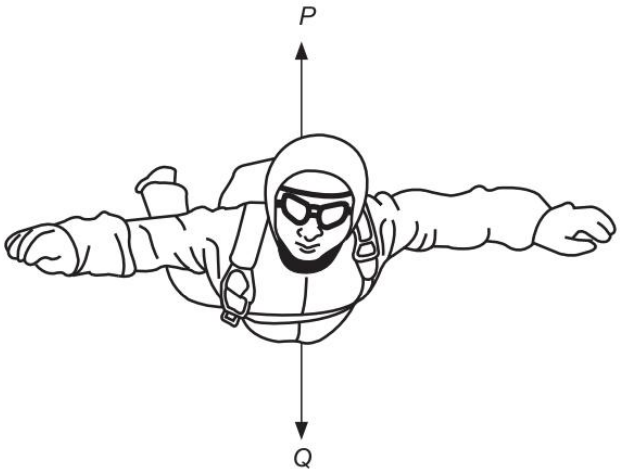
Solution

Yes. Its velocity keeps changing (because direction keeps changing), hence there is a resultant force causing the change. Resultant force acts towards the centre of the circle.

Example 3.4

A skydiver of mass 60 kg falls from rest vertically downwards at a constant velocity.

The figure shows the forces, *P* and *Q*, acting on him.



(a) Identify the forces *P* and *Q* acting on the skydiver.

(b) Explain why *P* is acting upwards.

(c) When the skydiver starts to fall from rest, the forces *P* and *Q* are unbalanced.

  (i) Find *P* and *Q* at $t = 0$ s.

  (ii) Find *P* and *Q* when the velocity of the skydiver is uniform.

  (iii) Describe, in terms of the forces acting on the sky diver, why the velocity of the skydiver increases before reaching terminal velocity.

Solution

(a) *P* is the air resistance on the skydiver and *Q* is the weight of the skydiver.

(b) Air resistance opposes the motion of the skydiver. Since the skydiver is falling vertically downwards, the air resistance acting on him is in the upward direction to oppose his motion.

(c) Take all forces acting downwards as positive.

(i) $P = 0$ N

$Q = mg = 60 \times 10 = 600$ N

(ii) When the velocity of the skydiver is uniform, he has reached terminal velocity. The resultant force acting on him is 0 N.

$Q - P = 0$

$P = Q = 600$ N

(iii) As a result of unbalanced forces, there will be a non-zero resultant force acting on the skydiver, and it is acting vertically downwards. By Newton's 2nd Law, the skydiver is accelerating downwards. Hence, the velocity of the skydiver increases before it reaches terminal velocity.

HOMEWORK QUESTIONS

1. A body of mass 5 kg accelerates at 2 m/s².
→ Calculate the force acting on it.

2. A force of 20 N acts on a mass of 4 kg.
→ Find the acceleration produced.

3. A 10 kg object is pushed with a force of 50 N.
→ What is its acceleration?

4. A car of mass 1000 kg accelerates at 3 m/s².
→ Calculate the force produced by the engine.

5. A force of 15 N acts on a body causing an acceleration of 3 m/s².
→ Find the mass of the object.

6. A 2 kg object experiences a force of 12 N.
→ What is its acceleration?

7. A truck of mass 2000 kg is acted on by a force of 4000 N.
→ Calculate its acceleration.

8. A force of 45 N produces an acceleration of 5 m/s².
→ Find the mass.

9. A 0.5 kg ball is hit with a force of 10 N.
→ What acceleration does it gain?

10. A 750 kg car increases its acceleration to 4 m/s².
→ Calculate the force acting on the car.