

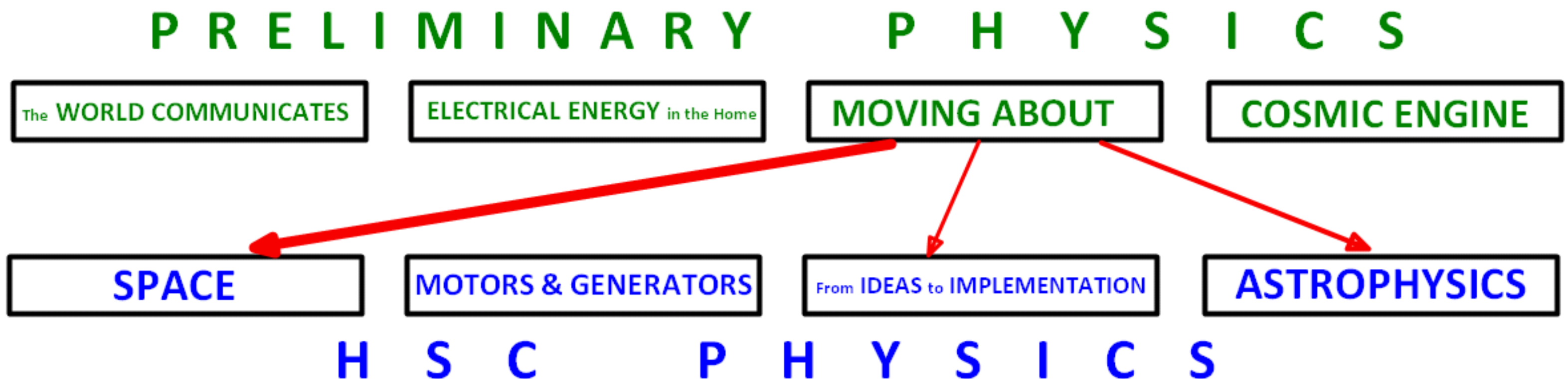
# MODULE 3: MOVING ABOUT

CIRCULAR MOTION, NEWTON'S 3RD LAW

PERIOD 4

4 AUGUST 2009

WEEK 2 / TERM 3 - TUESDAY



## MOVING ABOUT - 2

An analysis of the external forces on vehicles helps to understand the effects of acceleration and deceleration

*Students learn to:*

- describe the motion of one body relative to another
- identify the usefulness of using vector diagrams to assist solving problems
- explain the need for a net external force to act in order to change the velocity of an object
- describe the actions that must be taken for a vehicle to change direction, speed up and slow down
- describe the typical effects of external forces on bodies including:
  - friction between surfaces
  - air resistance
- define average acceleration as  $a_{av} = \frac{\Delta v}{\Delta t}$  therefore  $a_{av} = \frac{v - u}{t}$
- define the terms 'mass' and 'weight' with reference to the effects of gravity
- outline the forces involved in causing a change in the velocity of a vehicle when:
  - coasting with no pressure on the accelerator
  - pressing on the accelerator
  - pressing on the brakes
  - passing over an icy patch on the road
  - climbing and descending hills
  - following a curve in the road
- interpret Newton's Second Law of Motion and relate it to the equation  $\Sigma F = ma$
- identify the net force in a wide variety of situations involving modes of transport and explain the consequences of the application of that net force in terms of Newton's Second Law of Motion

## MOVING ABOUT - 2

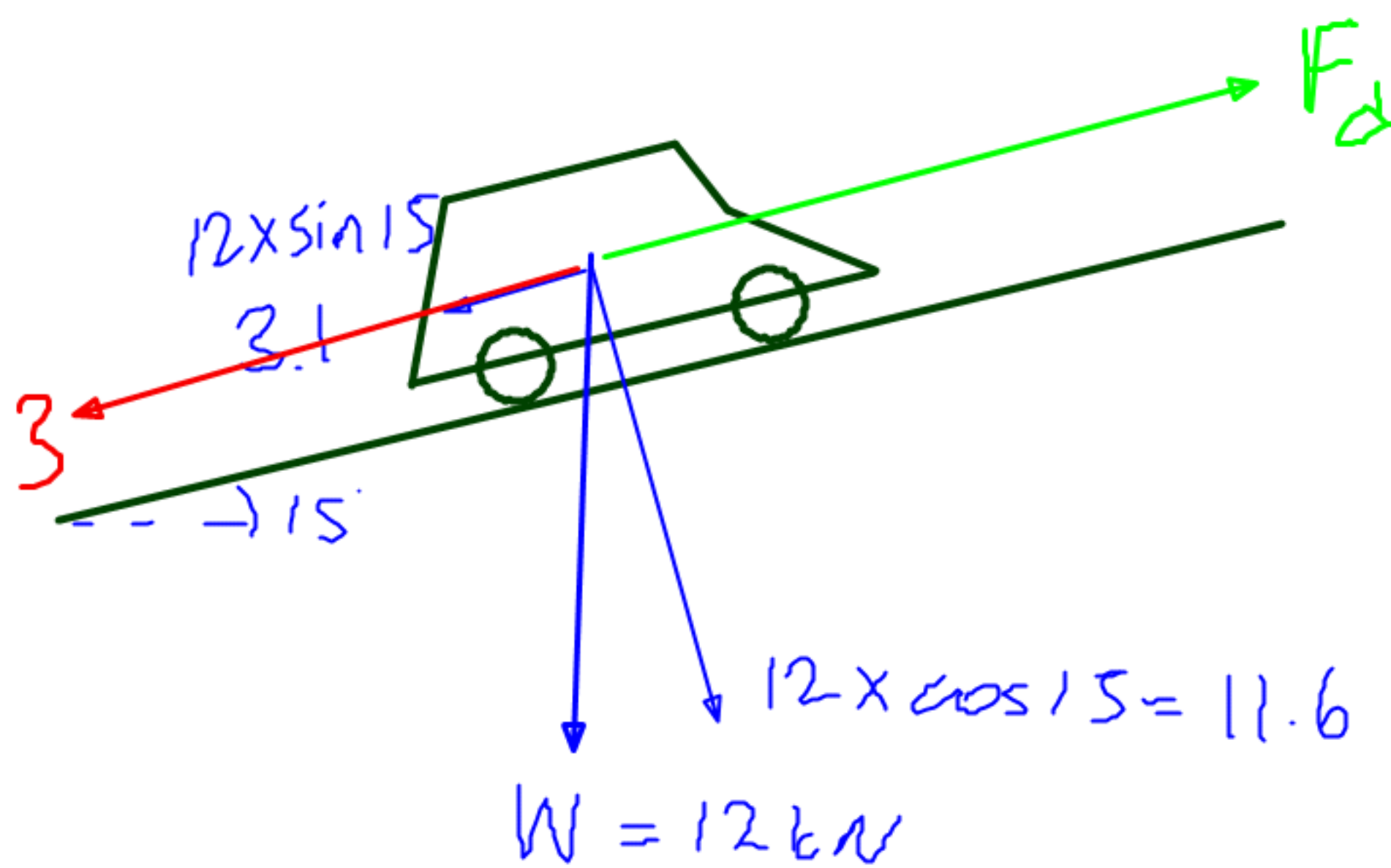
An analysis of the external forces on vehicles helps to understand the effects of acceleration and deceleration

*Students:*

- analyse the effects of external forces operating on a vehicle
- gather first-hand information about different situations where acceleration is positive or negative
- plan, choose equipment or resources for and perform a first-hand investigation to demonstrate vector addition and subtraction
- solve problems using vector diagrams to determine resultant velocity, acceleration and force
- plan, choose equipment or resources for and perform first-hand investigations to gather data and use available evidence to show the relationship between force, mass and acceleration using suitable apparatus
- solve problems and analyse information using  $\Sigma F = ma$  for a range of situations involving modes of transport
- solve problems and analyse information involving  $F = \frac{mv^2}{r}$  for vehicles travelling around curves



**Example:** A 1200-kg-car is travelling at constant velocity uphill on a slope of 15 degrees. If the total resistive forces is 25% of the weight for that particular speed, what must be the driving force and acceleration?



$$\begin{aligned} W &= m \cdot g \\ &= 1200 \times 10 \\ &= 12000 \text{ N} \\ &= 12 \text{ kN} \end{aligned}$$

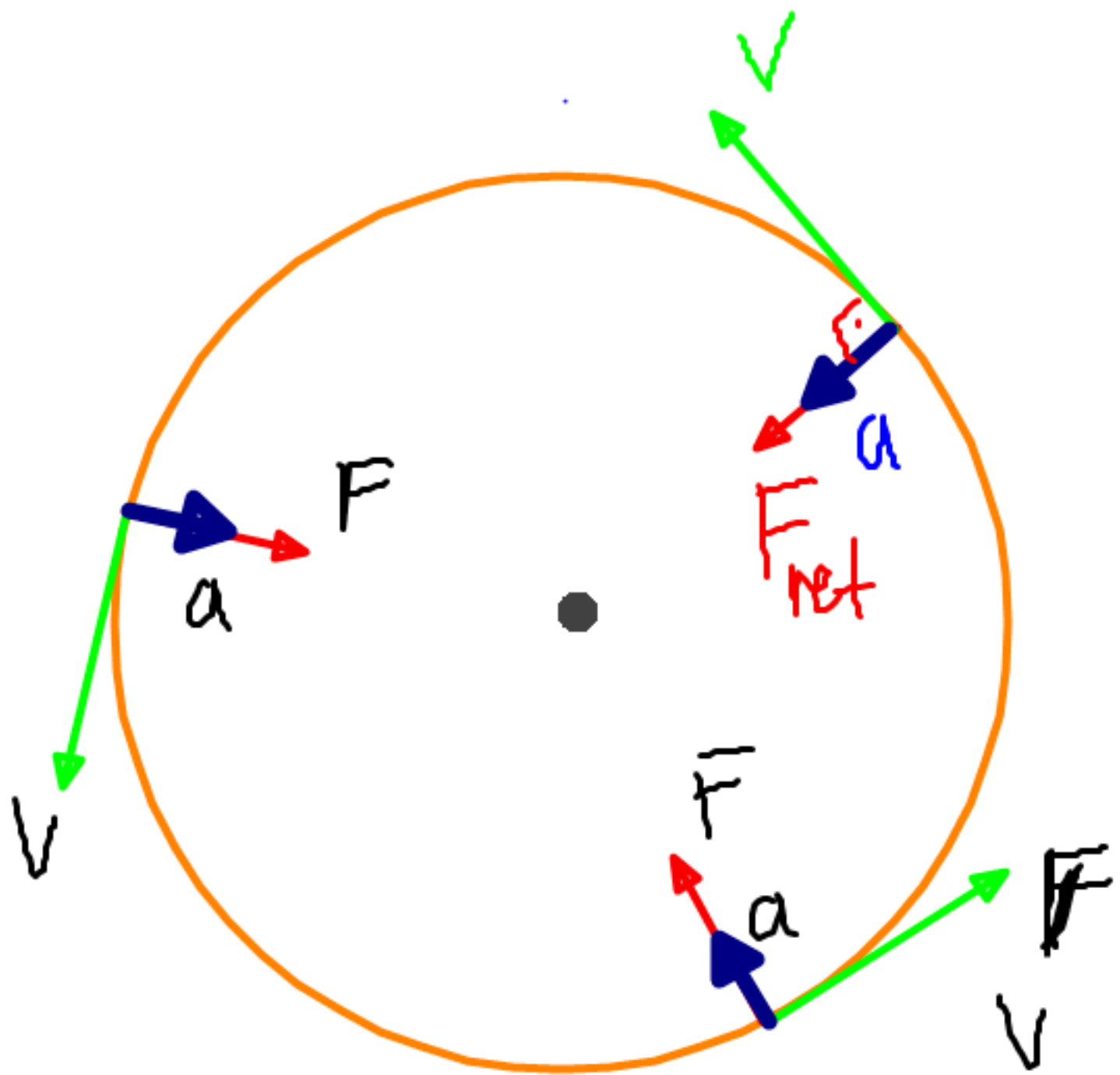
$$F_d = F_r + W_{\parallel}$$

3                  3.1

$$F_{\text{net}} = 0 \Rightarrow a = 0$$
$$v = \text{cst}$$

$$F_d = 6.1 \text{ kN}$$

## CIRCULAR MOTION



$$F_{\text{net}} = \frac{mv^2}{R} = m \cdot a = F_c$$

$$a = \frac{v^2}{R}$$

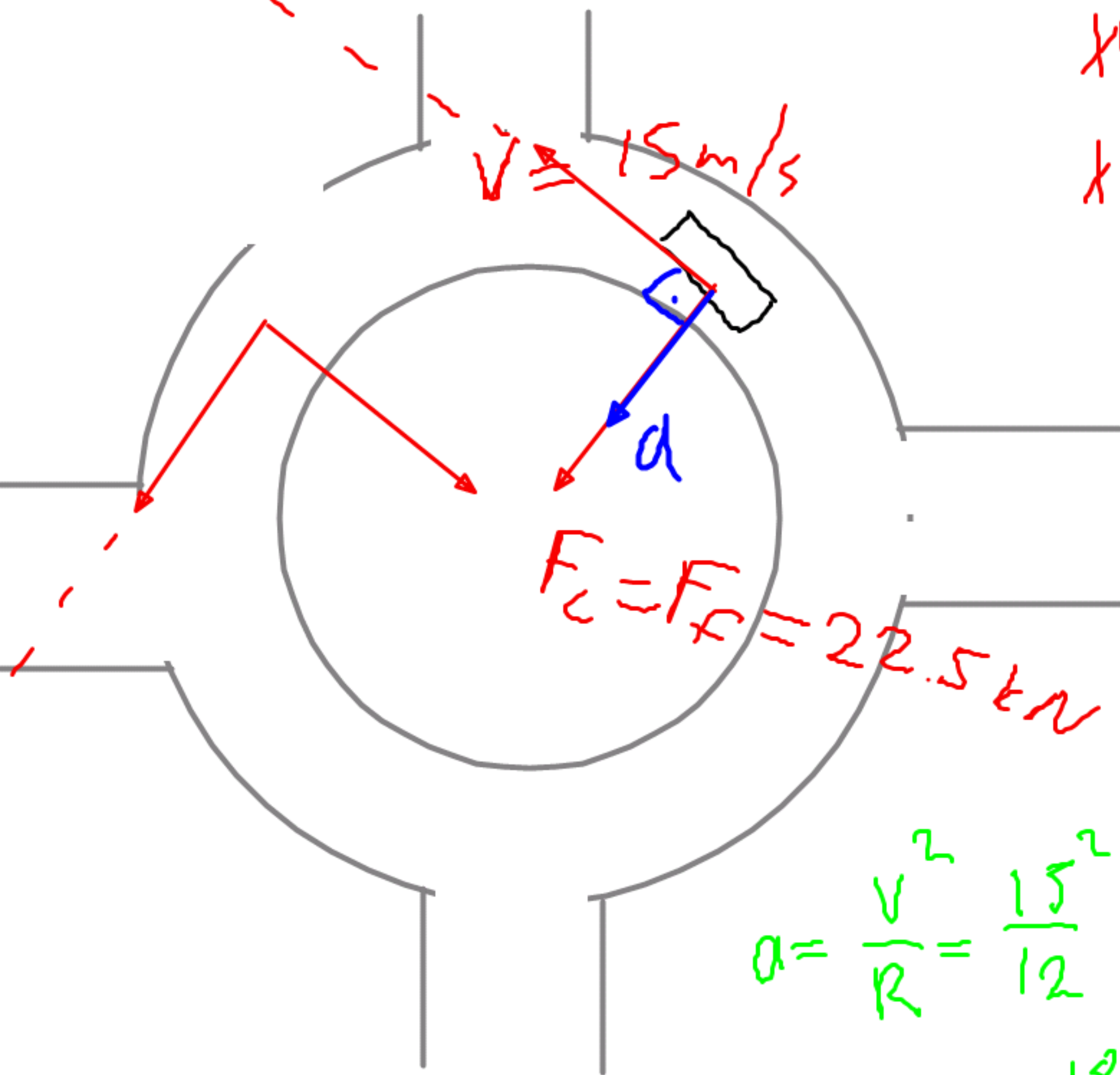
$$v = \frac{2\pi R}{T}$$

## 10.10 Calculating acceleration and net force around a curve

A car of mass 1200 kg is driven at a constant speed of  $15 \text{ m s}^{-1}$  around a curve with a radius of 12 m. Calculate:

- (a) the magnitude of acceleration of the car
- (b) the magnitude of net force acting on the car.

velocity is changing,  
there is  $a$ ,  
there is  $F_{\text{net}}$ .



$$F_{\text{net}} = F_c = \frac{mv^2}{R}$$
$$= \frac{1200 \times 15^2}{12}$$

$$a = \frac{v^2}{R} = \frac{15^2}{12}$$
$$= 18.8 \text{ m/s}^2$$
$$= 22500 \text{ N}$$



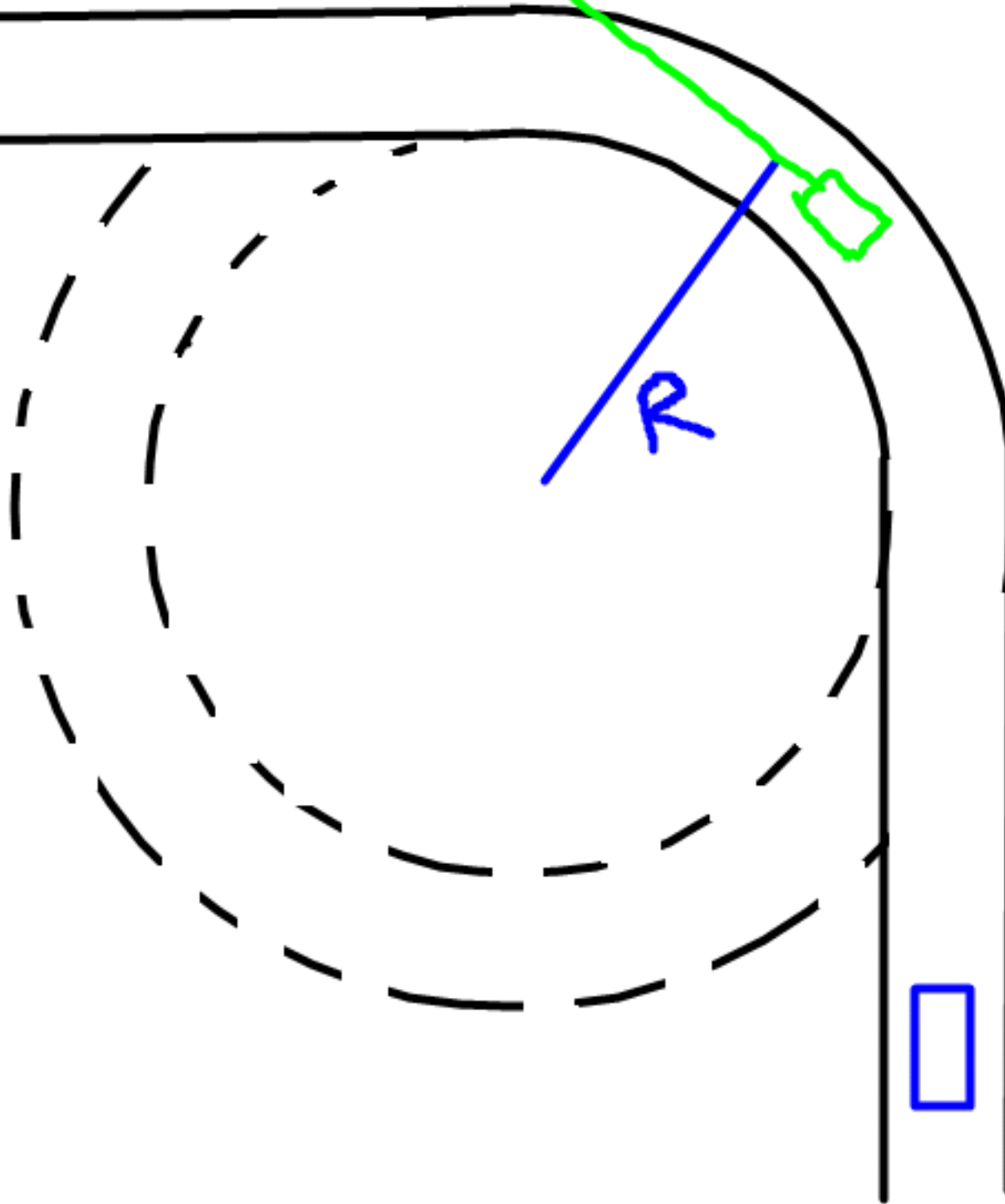
side view

**Exercise 2:** A car of mass 1450 kg is driven around a bend of radius 70 m. Determine the frictional force required between the tyres and the road in order to allow the car to travel at 70 km/h?

$$F_f = \frac{1450 \times 20^2}{70} = \frac{mv^2}{R}$$

$$= 8285 \text{ N}$$

$$v = 70 \text{ km/h} \approx 20 \text{ m/s}$$



~~150 km/h~~

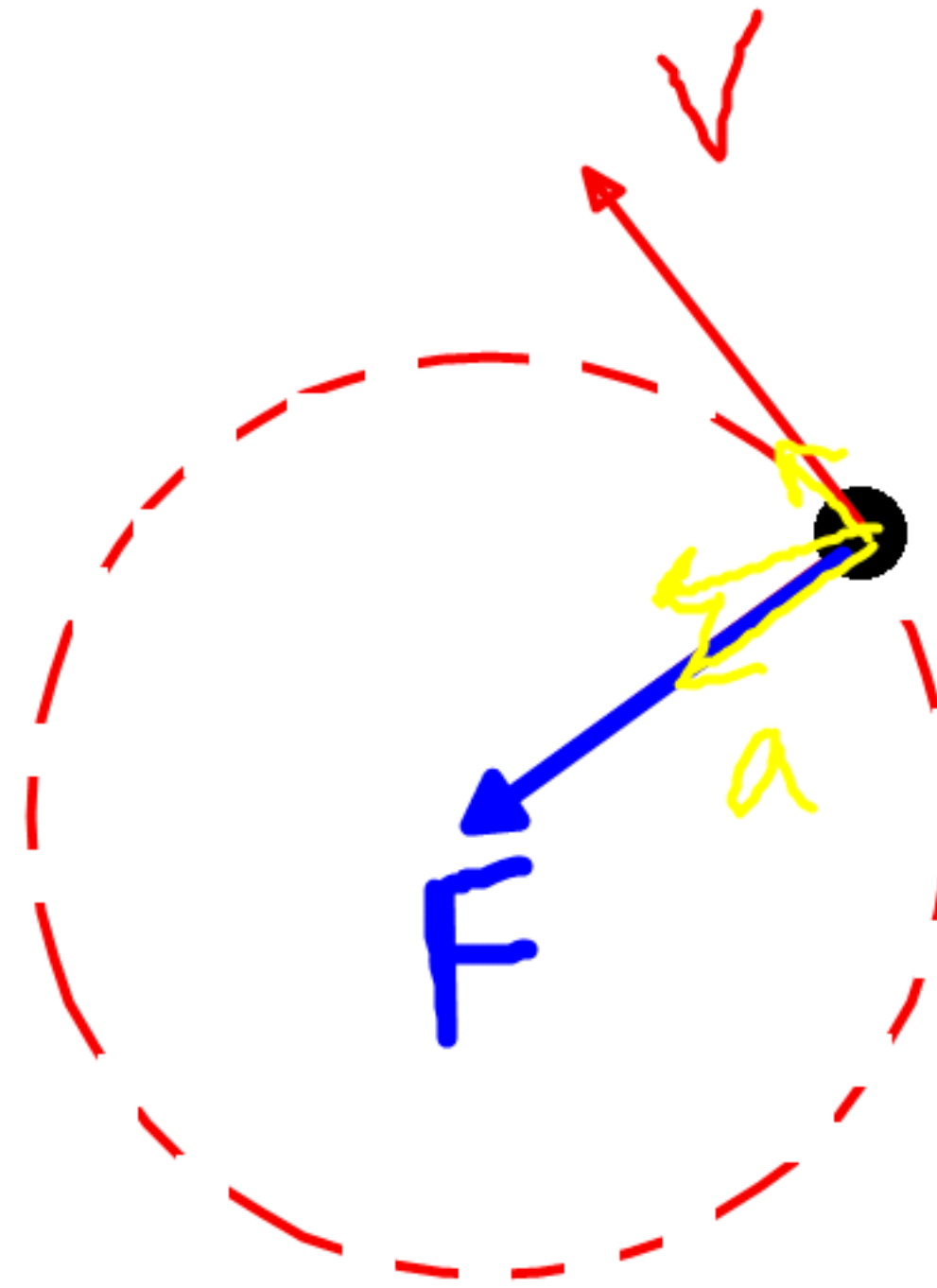
$$F_f = 35000 \text{ N}$$

$$1 \text{ km/h} = \frac{1}{3.6} \text{ m/s}$$

$$1 \text{ m/s} = 3.6 \text{ km/h}$$

**Exercise 1:** A rock of mass 250 g is attached to the end of a 1.5 m long string and whirled in a horizontal circle at 15 m/s. Show the velocity, acceleration and net force on the rock and then calculate the centripetal force and acceleration of the rock.

$$F_c = T_{\text{string}}$$





## SOURCES OF CENTRIPETAL FORCE

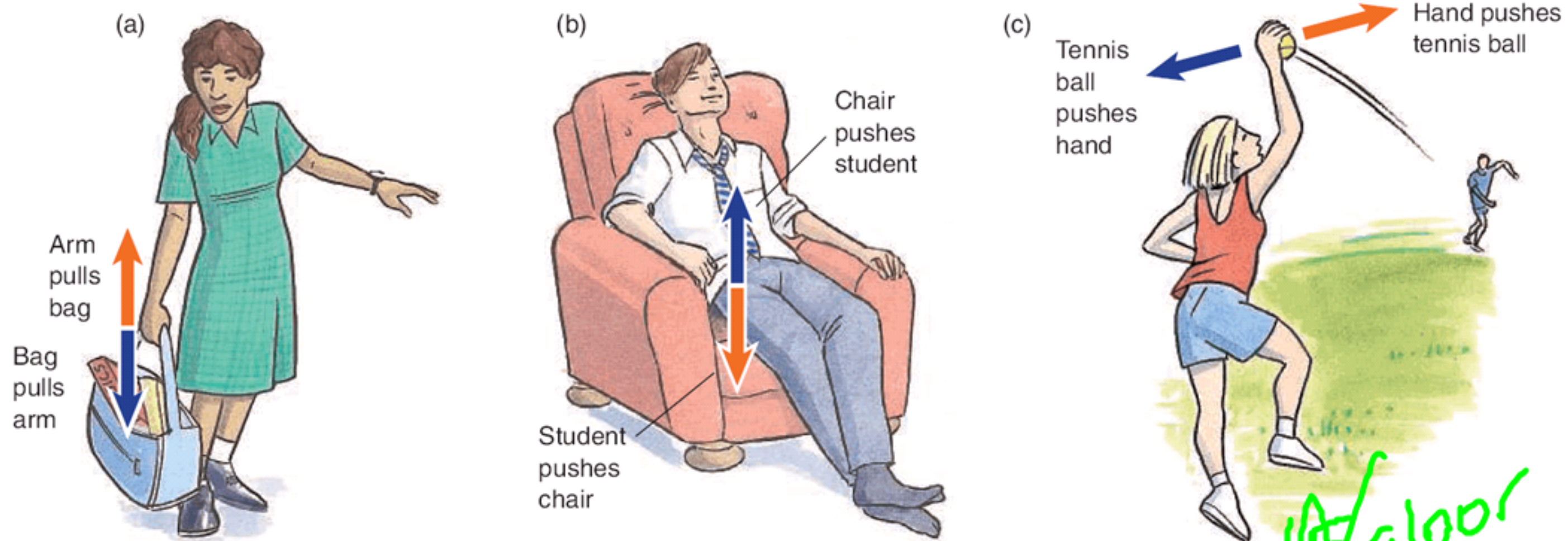
MOTION	$F_c$ PROVIDED BY ...
Whirling rock on a string	The string
Electron orbiting atomic nucleus	Electron–nucleus electrical attraction
Car cornering	Friction between tyres and road
Moon revolving around Earth	Moon–Earth gravitational attraction
Satellite revolving around Earth	Satellite–Earth gravitational attraction

## NEWTON'S FIRST LAW OF MOTION

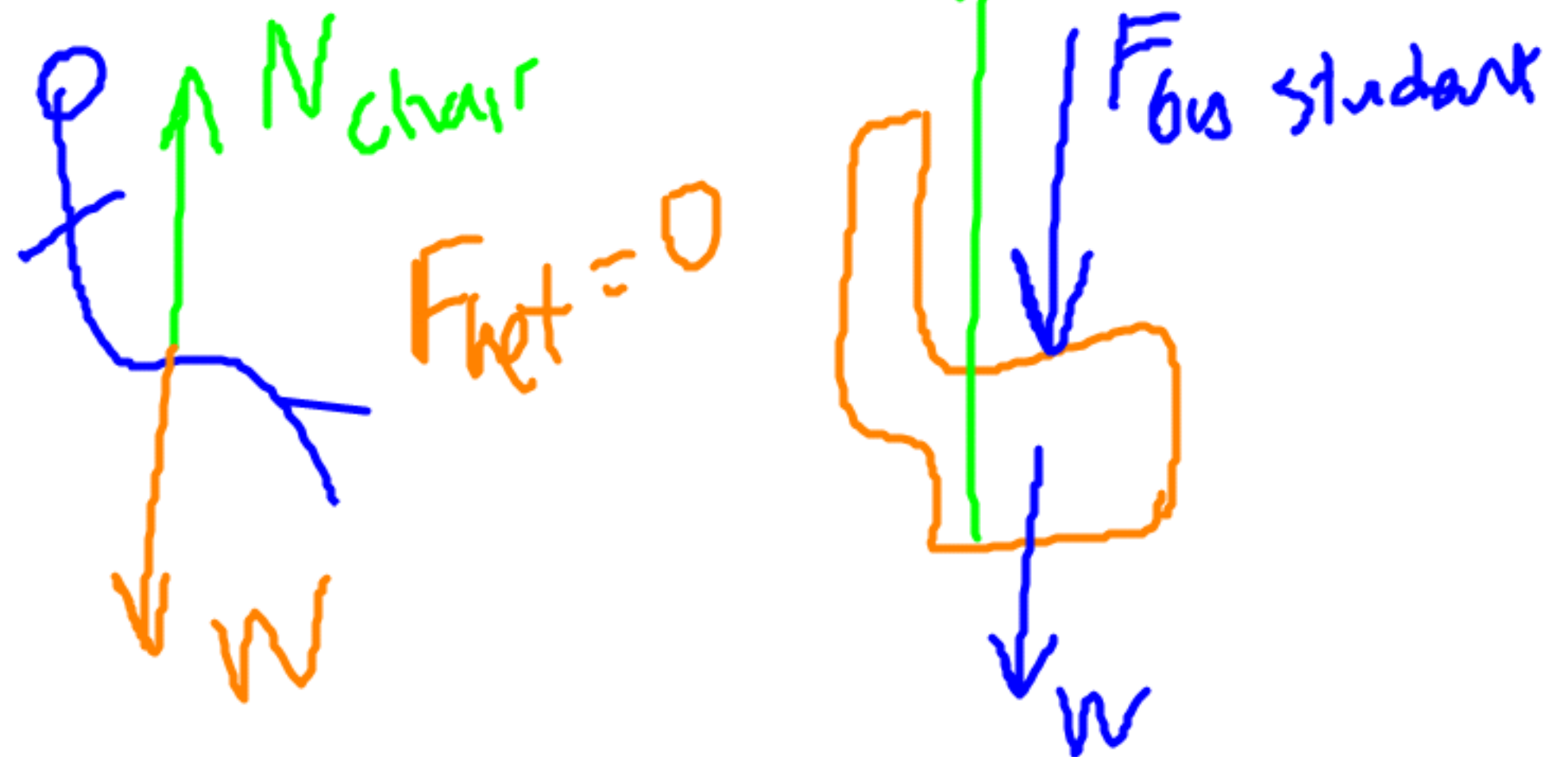


## NEWTON'S SECOND LAW OF MOTION

# NEWTON'S THIRD LAW OF MOTION



**Figure 10.17** Forces always act in pairs. (a) The arm pulls up on the bag; the bag pulls down on the arm. (b) The student pushes down and back on the chair; the chair pushes up and forward on the student. (c) The hand pushes on the ball; the ball pushes on the hand.





## **NEWTON'S THIRD LAW OF MOTION IN ACTION**

In fact, none of your forward motion, whether you are on land, water or in the air, could occur without an action–reaction pair of forces.

- ✓ When you swim, you push the water backwards with your hands, arms and legs. The water pushes in the opposite direction, propelling you forwards.
- ✓ In order to walk or run, you push your feet backwards and down on the ground. The ground pushes in the opposite direction, pushing forwards and up on your feet.
- ✓ The forward driving force on the wheels of a car is the result of a push back on the road by the wheels.
- ✓ A jet or a propeller-driven plane is thrust forwards by air. The jet engines or propellers are designed to push air backwards with a very large force. The air pushes forward on the plane with an equally large force.

### **OTHER EXAMPLES:**

✓

✓

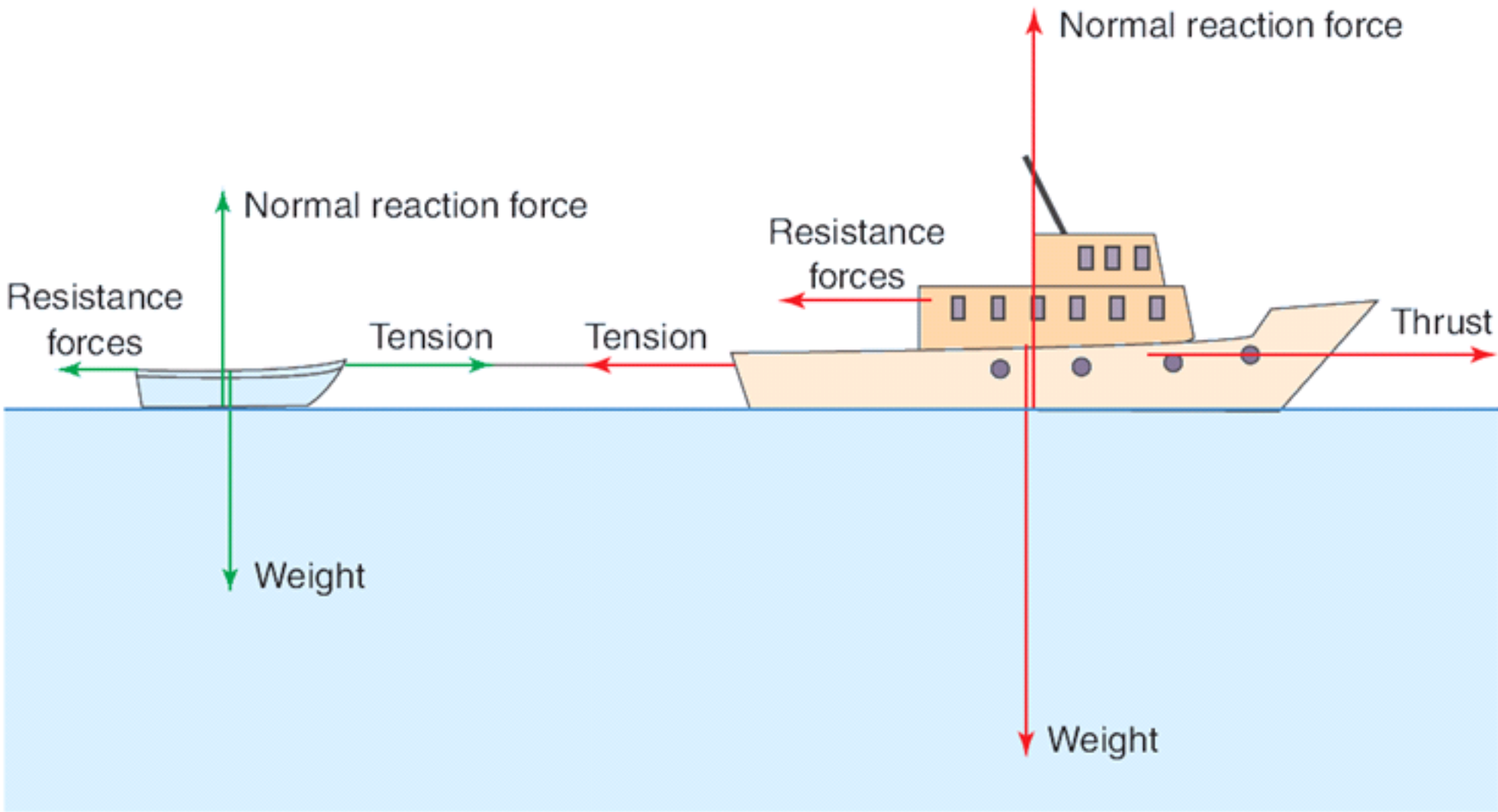
✓

✓

✓



MULTIPLE BODIES - 3RD LAW IN ACTION



## 10.9

### *Forces on a car and trailer*

A car of mass 1600 kg tows a trailer of mass 400 kg. The coupling between the car and trailer is rigid. The driving force acting on the car as it starts from rest is 5400 N in an easterly direction. The frictional forces resisting the motion of the car and trailer are insignificant and can be ignored. Calculate:

- (a) the acceleration of the car and trailer
- (b) the net force acting on the trailer
- (c) the force applied on the trailer by the car
- (d) the force applied on the car by the trailer.





# HOMEWORK

- ★ Homework is an integral part of your "Learning Curve", take it seriously!
- ★ If you cannot do all, at least do a few from each piece
- ★ Target minimum 1 hour of Physics everyday
- ★ Homework is due next period, unless otherwise stated

*Apart from reading the relevant pages from the textbook your homework is:*

1. Read all pages and study worked examples of Chapter 10.
2. Yellow Worksheet all questions
3. Chapter 10 questions - odd numbered ones

4. log on to

"<http://www.academicearth.org/courses/physics-i-classical-mechanics>"  
and watch lecture 5 and 6





