ARE YOU INFECTED WITH MISCONCEPTIONS?

DESCRIPTIF DE L'ACTIVITE DESTINE AU PROFESSEUR

Compétences exigibles du B.O.	***Préambule du programme du cycle terminal de la voie S :*** […] en devant présenter la démarche suivie et les résultats obtenus, l'élève est amené à une activité de communication écrite et orale susceptible de le faire progresser dans la maîtrise des compétences langagières, orales et écrites, dans la langue française, mais aussi en langue étrangère, notamment en anglais, langue de communication internationale dans le domaine scientifique. […]
	Programme de terminale S : Temps, cinématique et dynamique newtoniennes (Lois de Newton).
Déroulement de l'activité	Cette activité de **remédiation** est prévue pour une durée d'une heure (voire 1h30 selon le niveau de compétence de la classe) en séance d'accompagnement personnalisé. Dans un premier temps (activité 1), elle permet de faire le point sur la connaissance du principe d'inertie étudié en seconde et de rappeler la seconde loi de Newton. Si l'élève est en difficulté, alors une situation-problème lui est proposée (activité 2). L'objectif est ici de faire émerger les fausses représentations par une approche phénoménologique, sans avoir recours au formalisme mathématique. On raisonne ainsi comme cela est pratiqué dans les pays anglo-saxons. De fait, cette activité participe d'une dimension culturelle. Dans un second temps, l'activité 3 permet de dresser une carte mentale présentant le principe de l'inertie et la seconde loi de Newton. Dans un dernier temps, des exercices courts permettant une mise en application de la seconde loi de Newton sont proposés. On est ici dans la logique du questionnement proposé au A-level (équivalent de notre baccalauréat). Une des questions de l'activité 4 permet d'approfondir la notion de projection de forces.
Compétences évaluées	Compétences linguistiques : • compréhension écrite de la langue anglaise ; • expression écrite. En plus des compétences linguistiques, cette activité permet de travailler les compétences de la démarche scientifique : • s'approprier (APP) ; • analyser (ANA) ; • réaliser (REA).
Remarques	Cette activité peut se décliner selon trois niveaux de compétences : • niveau 1 : une fiche coup de pouce permet de donner le vocabulaire nouveau (ou qui pose problème) directement en français (fiche 1). • niveau 2 : le vocabulaire nouveau est introduit sous forme écrite par le biais de fiche coup de pouce proposant les définitions en anglais (fiche 2). • niveau 3 : le vocabulaire nouveau (ou qui pose problème) est explicité oralement par l'enseignant. Certains exemples sont tirés du site : http://www.physicsclassroom.com/
Auteurs	Séverine Leget – Lycée Marceau – Chartres Delphine Pailler – Lycée Paul-Louis Courier – Tours Florence Trouillet – Lycée Claude de France – Romorantin

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Compétences travaillées (capacités et attitudes) :

- **APP :** mobiliser ses connaissances, extraire des informations utiles.
- **ANA** : exploiter des informations ; adopter une démarche explicative ; appliquer un modèle.
- **REA :** réaliser des calculs ; appliquer une consigne.

INTRODUCTION

Isaac Newton built on Galileo's thoughts about motion. He stated three laws concerning motions and forces. Do you feel free with each of them?

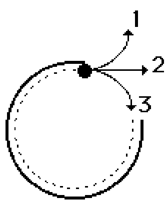
ACTIVITY 1: CHECK YOUR UNDERSTANDING

1. Imagine a place in the cosmos far from all gravitational and frictional influences. Suppose that you visit that place and throw a rock. The rock will …
   a. *gradually stop*
   b. *continue in motion in the same direction at constant speed*
   c. *continue in motion in the same direction at increasing speed*

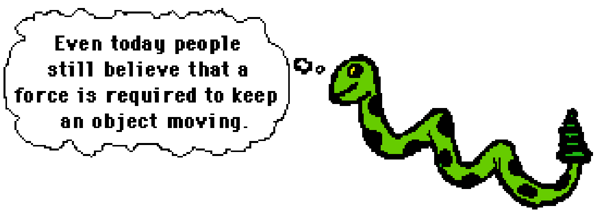
2. A 2 kg object is moving horizontally with a speed of 4 m/s. How much net force is required to keep the object moving at this speed and in this direction?
   a. *F = 0 N*
   b. *F = 0.5 N*
   c. *F = 8 N*

3. Supposing you were in space in a weightless environment, would it require a force to set an object in motion?
   a. *Yes*
   b. *No*
   c. *It depends on the temperature*

4. Several physics teachers are taking some time off to play a little golf. The 15th hole at the Golf Course has a large metal rim which putters must use to guide their ball towards the hole. Mr. Woods guides his golf ball around the metal rim. When the ball leaves the rim, which path (1, 2, or 3) will the golf ball follow?



5. Among the following sentences explaining Newton's second law, choose the right one.
   a. *Net force is equal to the product of the mass and the velocity*
   b. *Force is equal to the product of the mass and the acceleration*
   c. *Net force is the mass multiplied by the acceleration*

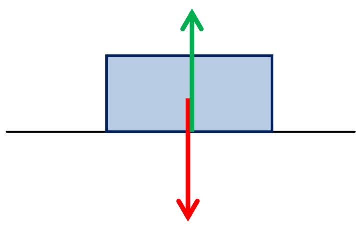


If your mark is less than 3 out of 5, then do the following activity (activity 2). Otherwise, go to the third activity.

ACTIVITY 2: ARE YOU INFECTED WITH THE BIG MISCONCEPTION? (NEWTON'S 1ST LAW)

You can receive jokers to help you. Just ask for them if you need help! **JOKERS N°1 AND N°2**

Two students, Anna Litical and Noah Formula, are discussing their physics homework prior to class. They are discussing an object that is being acted upon by two individual forces (both in a vertical direction); the free-body diagram for the particular object is shown on the right.



During the discussion, Anna suggests to Noah that the object under discussion could be moving. In fact, Anna suggests that if friction and air resistance could be ignored (because of their negligible size), the object could be moving in a horizontal direction with a constant speed.

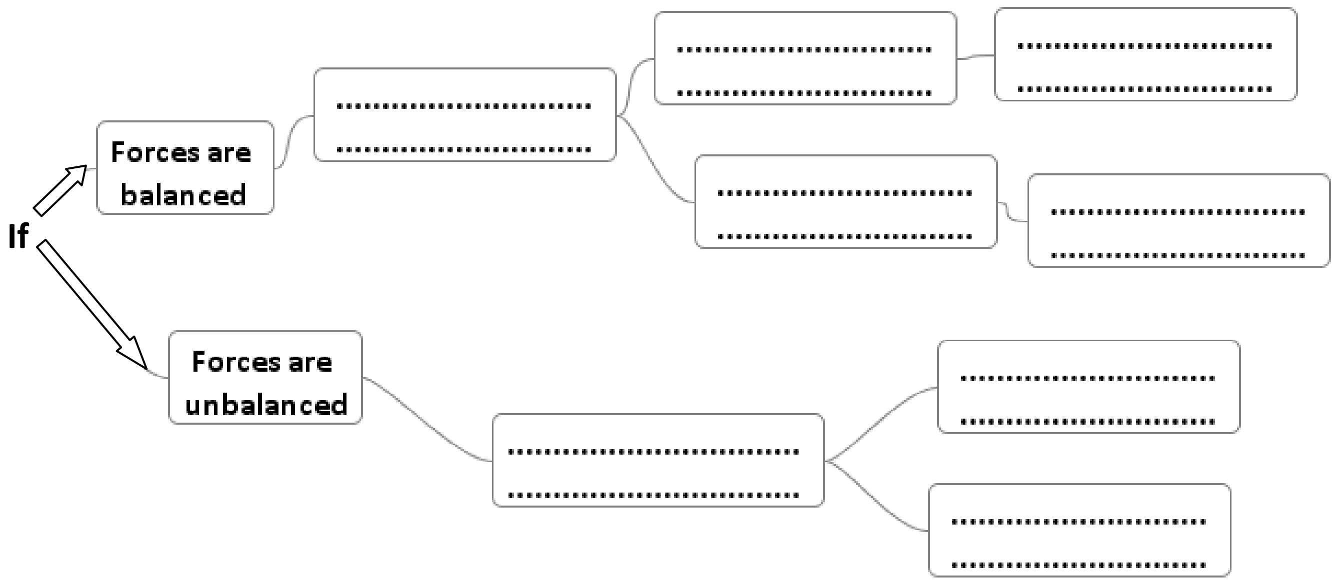
Noah objects, arguing that the object could not have any horizontal motion if there are only vertical forces acting upon it. Noah claims that the object must be at rest, perhaps on a table or floor. After all, says Noah, an object experiencing a balance of forces will be at rest.

- Who do you agree with?
- Justify briefly and find some examples or counter-examples.

ACTIVITY 3: PUT A BIT OF ORDER (NEWTON'S LAWS OF MOTION)

The two branches that make up this mind map are for the first one: ***Newton's first law***, and for the second one: ***Newton's second law***. Using the following labels, try to fill in the blanks:

- a = 0 m/s^2
- Speed is nil (V = 0 m/s)
- There is an acceleration
- Object at rest
- Object stays in motion (*same speed and direction*)
- The acceleration depends directly on the "net force"
- The acceleration depends inversely on the object's mass
- Speed is different from nil and constant



The first branch shows, against all common sense, that a body can move without a force being exerted.
The second one tells us what happens when unbalanced forces act. This is expressed in a very important equation of mechanics $\vec{F} = m.\vec{a}$ which will be used in the fourth activity thereafter.

ACTIVITY 4: SIMPLE CALCULATION AND A LITTLE THINKING (NEWTON'S SECOND LAW)

(a) Free-body diagrams are shown for a variety of physical situations. Use Newton's second law of motion to fill in all blanks. Use the approximation that $g \approx 10$ m/s².

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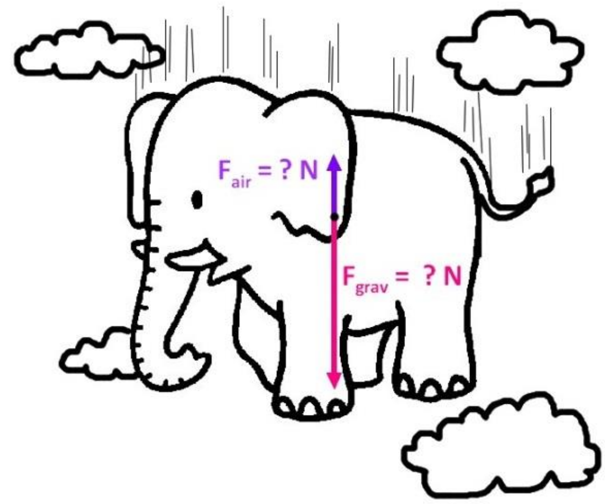

m = 10000 kg a = 8.0 m/s^2, down

$\sum F$ = …………… F_{grav} = …………… F_{air} = ……………
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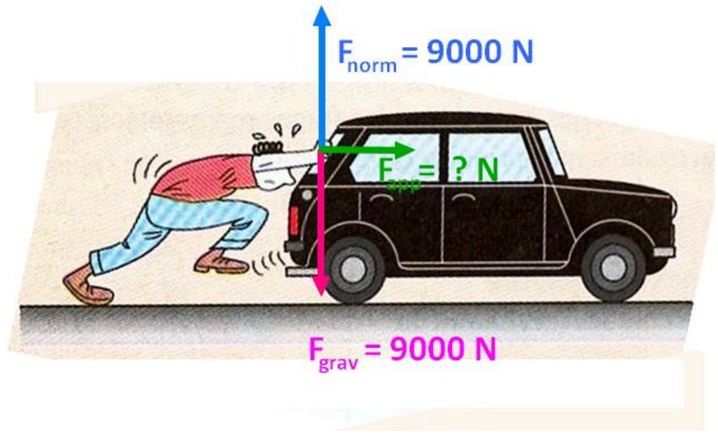

m = …………………… a = 1.5 m/s^2, right

$\sum F$ = ……………… F_{app} = …………………
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(b) An 80 kg skier has a force of 200 N exerted on him down the slope. There is no friction.

1. Calculate his acceleration down the slope.

……

2. Is the slope less than or more than 45°? Explain your answer.

……

……

If you need help, you can receive jokers. Just ask for them! **JOKERS N°3 AND N°4**

(c) A 50 g tennis ball may be accelerated at 1000 m/s^2 to reach a service speed of 130 mph.

1. Calculate the force required to accelerate the ball.

……

……

2. Is your answer reasonable? Comment.

……

……

CONCLUSION

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

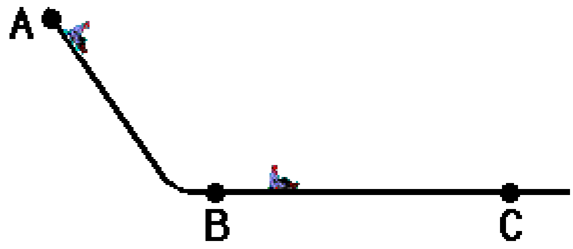
If the forces acting on an object are balanced and the object is in motion, then it will continue in motion with the same velocity.

JOKERS FOR ACTIVITY 2

Joker 1:

Do you remember last winter when you went sledding down the hill and across the level surface at the local park?

Imagine a the moment that there was no friction along the level surface from point B to point C and that there was no air resistance to impede your motion. How far would your sled travel? And what would its motion be like?



Joker 2:

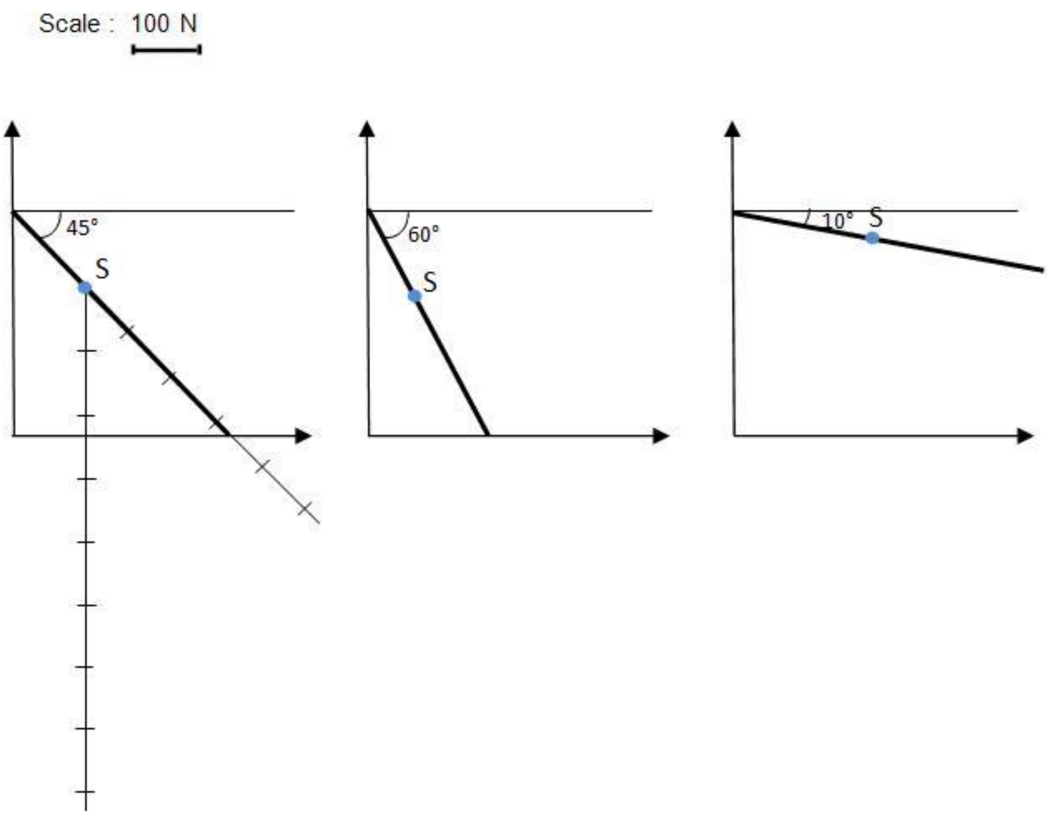
Slide a book across a table and watch it.

Why does it come to a rest position?
Is it because of the absence or of the presence of a force?

JOKERS FOR ACTIVITY 4-b-2)

Joker 3 :

-Diagram the forces $\vec{F}_{grav}$, $\vec{R}$ (the ground reaction force), $\vec{F}$ (200 N down the slope), acting on the skier for each tilt of the ski run: 45°, 60°, 10°.



- Draw the sum of the two forces ($\vec{F}_{grav}$, $\vec{R}$): this is the net force $\vec{F}_T$.

- Explain, in each case, if the net force is in accordance with the data given in the terms of the problem.

- Which situation could be likely if there were frictional forces?

Joker 4 :

- Using the formula: $\sin\theta = \frac{F_T}{F_{grav}}$, determine the tilt of the slope in degrees if: $F = F_T$ = 200 N.

- The relationship between an angle in degrees "θ" and the percent slope "p" is: $p = 100 \times \tan\theta$.
  Find the percent slope corresponding to the angle deduced in the first question.

- Look at the two documents below to determine if the slope is steep or not, and to state which kind of ski run the skier goes down. Don't forget the caption under the photo.

25% slope during climbing, Jebel Oftal in southern Morocco (Marathon des Sables 2008)

Colors of ski runs	Percent slope (%)
Green	0-15
Blue	15-25
Red	25-35
Black	>35

Percent slope for different ski runs

the net force	la résultante des forces
a putter	un club de golf
a rim	un cerceau (ici)
a path	une trajectoire
prior to class	avant le cours
to claim	prétendre
balanced	équilibré(es)
a counter-example	un contre-exemple
a sled	un traîneau
to go sledding	partir en traîneau
to impede	empêcher
to slide	glisser
mind map	carte mentale ou carte heuristique
velocity	vecteur vitesse (quatre caractéristiques : direction, sens, norme et point d'application)
speed	désigne uniquement la norme du vecteur vitesse
a slope	une pente
mph	miles per hour (1 mph ≈ 1.6 km/h)
the ground reaction force	la réaction du support (si on néglige les frottements, cette force est perpendiculaire au support)

the net force	the final force when all forces acted on the object have been summed together.
a putter	a putter is a club used to make relatively short and low-speed strokes in order to roll the ball into the hole.
a rim	the edge at the top of the hole. *The rim of a cup.*
a path	the line along which something moves.
prior to class	before the class.
to claim	to say that something is true without having any proof.
balanced	showing an equal value in relation to something else.
counter-example	an example to disprove (= to contradict) a theory.
a sled (or sledge)	vehicle often pulled by dogs and used for travelling on snow.
to go sledding	to go down hills with such a vehicle.
to impede	to make the motion difficult.
to slide	to move smoothly along a surface.
mind map	a diagram where ideas are summed up in boxes.
velocity	velocity is a vector quantity, it is defined as the speed in a particular direction and from a specified origin.
speed	speed is a scalar, it is a simple measure to describe how fast something is moving.
a slope	a surface that goes up or down. *The most difficult ski slopes are black.*
mph	miles per hour (1 mph ≈ 1.6 km/h)
the ground reaction force	this is the force exerted by the ground on a body in contact with it. If there is no friction, the ground reaction force coincides with the notion of a normal force. In a more general case, the ground reaction force will also have a component parallel to the ground.

ANSWERS

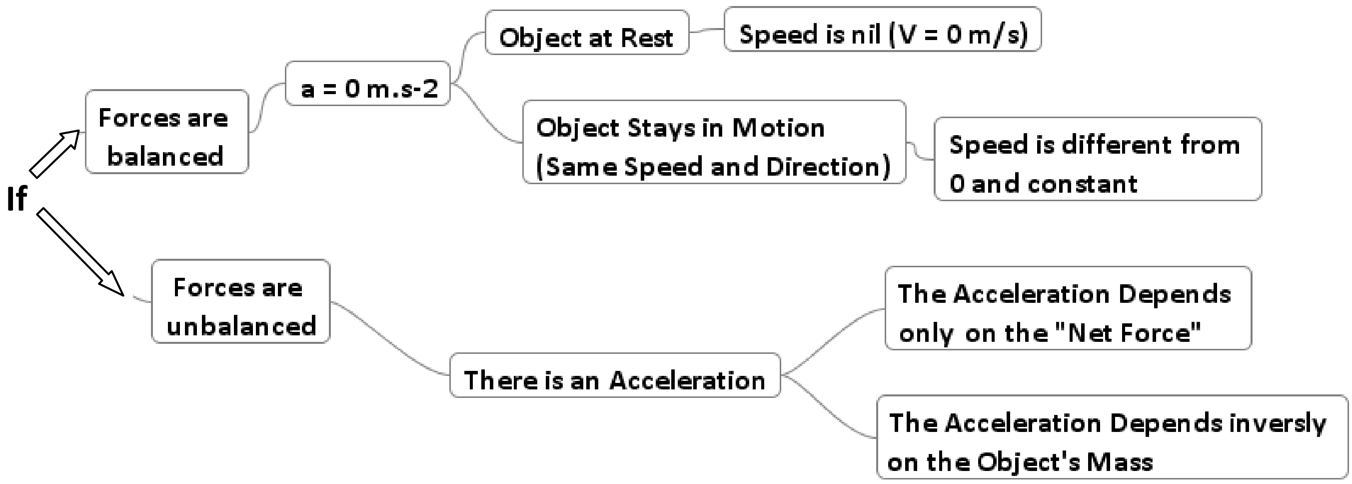
Activity 1: (APP ANA)

1. *Answer b.*
2. *Answer a.*
3. *Answer: yes! Even in space, objects have mass! A force must be applied to set a stationary object in motion.*
4. *Answer 2: once the ball leaves the rim it will follow an inertial path (it will continue in a straight line in its current direction). Once the ball leaves the rim, there are no more unbalanced forces to change its state of motion)*
5. *Answer c.*

Activity 2: (APP ANA)

Anna Litical is right. For instance, the Voyager space probe only uses its engines to change direction and still go further on, without any propulsion and far away from the attractive gravitational forces of planets. Furthermore, in a Galilean frame of reference, direction or speed of an object is modified as soon as soon as unbalanced forces act on (try to find an example where unbalanced forces act on an object staying at rest or moving in a straight line with a constant speed …)

Activity 3: (APP ANA)



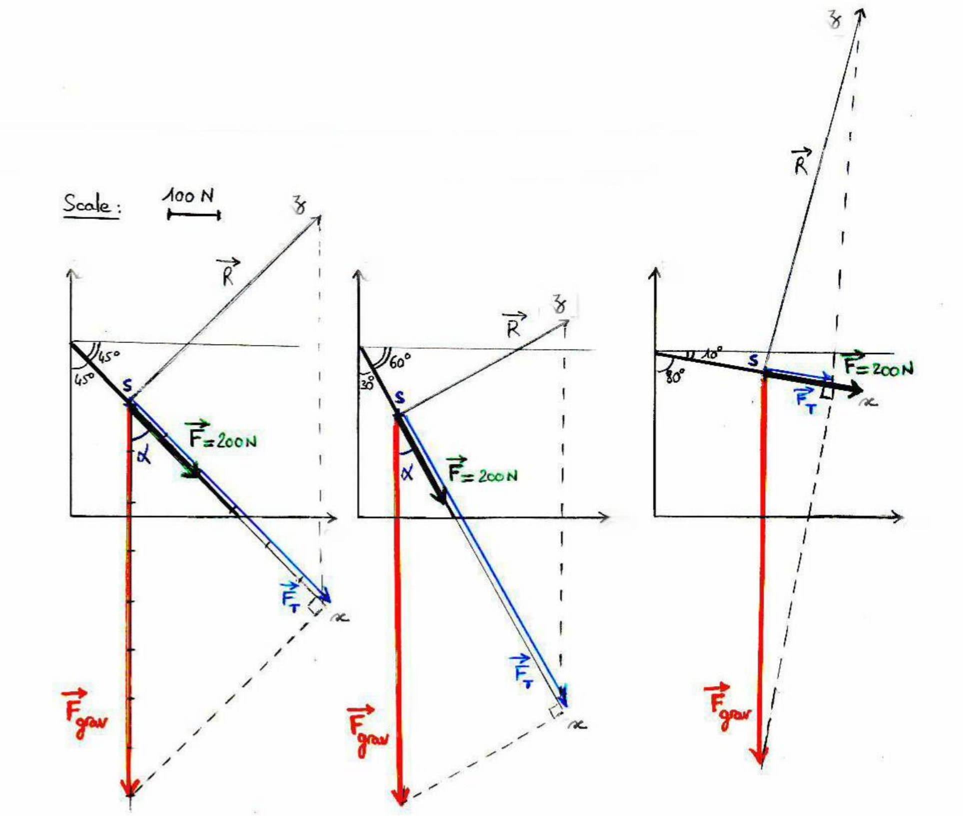
Activity 4: (APP ANA REA)

(a) Elephant: $\sum F = m.a$ = <u>80000 N</u> ; $F_{grav} = m \times g$ = <u>100000 N</u> ; $F_{grav} - F_{air}$ = 80000 N $\Rightarrow$ F_{air} = <u>20000 N</u>

Car: $F_{grav} = m \times g = 9000$ N $\Rightarrow$ m = <u>900 kg</u> ; $\sum F = m.a = 900 \text{ kg} \times 1.5 \text{ m/s}^2$ = <u>1350 N</u> (right); $\sum \vec{F} = \vec{F}_{grav} + \vec{F}_{norm} + \vec{F}_{app} = \vec{0} + \vec{F}_{app}$ $\Rightarrow$ F_{app} = <u>1350 N</u>

(b) $a = \frac{F}{m} = \frac{200\text{N}}{80\text{kg}}$ = 2.5 m/s^2

Activity 4-(b)-2) joker 3:



The weight can be resolved into x and z components, parallel and perpendicular to the incline. And using trigonometry, we can deduce that: $\cos\alpha = \frac{F_T}{F_{grav}}$ thus $\cos\alpha = \frac{F_T}{m \times g}$.

1st situation, slope is 45°: $F_T = \cos\alpha \times m \times g = \cos 45° \times 80 \times 10 = \frac{80 \times 10}{\sqrt{2}} \approx 5.7 \times 10^2$ N

⇒ Slope is less than 45° because at this angle, force down slope = weight / $\sqrt{2}$, which is greater than 200 N.

2nd situation, slope is 60 ° (α = 30°): $F_T = \cos\alpha \times m \times g = \cos 30° \times 80 \times 10 = \frac{80 \times 10 \times \sqrt{3}}{2} \approx 6.9 \times 10^2$ N

⇒ Of course, slope is less than 60° too, for the same reason.

3rd situation, slope is 10°: $F_T = \cos\alpha \times m \times g = \cos 80° \times 80 \times 10 \approx 1.4 \times 10^2$ N

⇒ This situation could be likely if there were frictional forces.

Activity 4-(b)-2) joker 4:

$\sin\theta = \frac{F_T}{F_{grav}} = \frac{200}{80 \times 10}$ thus: $\theta = 14°$, consequently slope θ is less than 14° ⇒ $p = 100 \times \tan 14 = 26$ %

The slope calculated is roughly the same than the one shown on the picture. It seems very steep. The skier probably goes down a red run.

(c) F = ma = 0.050 kg × 1000 m/s^2 = 50 N

Not very large – as you can probably lift 250 N with one arm.