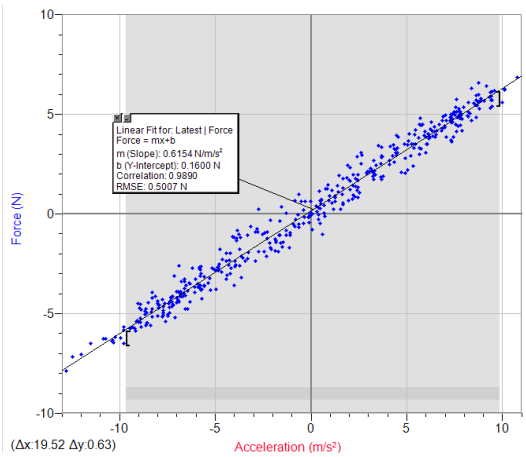
Teachers' notes

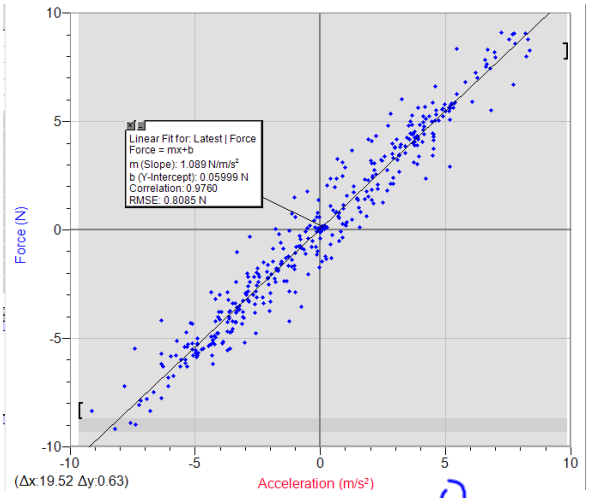
Lesson notes

Newton's 2nd Law

1) Students will be able to describe Newton's 2nd law of motion.

2) Students will be able to apply Newton's 2nd law in a variety of situations.





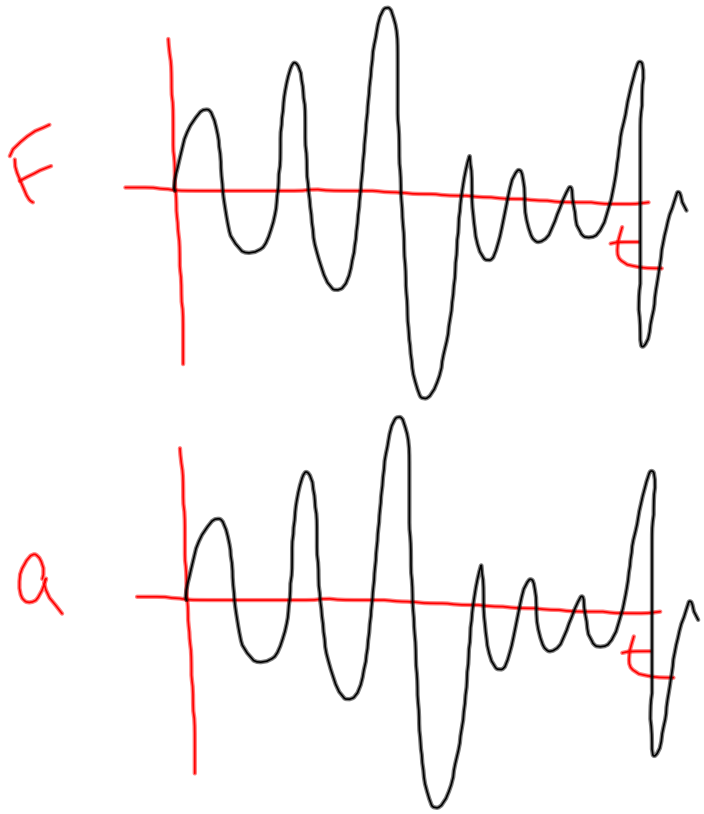
$$\cancel{y}\,F = m\cancel{x}\,a + \cancel{b}^{\,0}$$

$$F = (1.089\ N/m/s^2)\,a$$

$$\boxed{F = ma}$$

$$F = mg$$

$$(N) = kg\ m/s^2$$



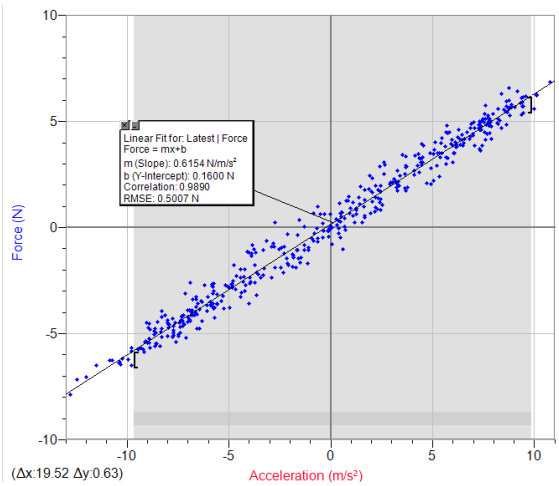
$$\frac{(N)}{m/s^2} \rightarrow m, kg, s$$

$$\frac{kg\,\cancel{m/s^2}}{\cancel{m/s^2}} = kg$$

$$F = ma$$

$$(N) = (kg)(m/s^2)$$

$$1N = 1\,kg\,m/s^2$$


Linear Fit for: Latest | Force
Force = mx+b
m (Slope): 0.6154 N/m/s²
b (Y-Intercept): 0.1600 N
Correlation: 0.9890
RMSE: 0.5007 N
Force (N)
Acceleration (m/s²)
(Δx:19.52 Δy:0.63)
10
5
0
-5
-10
-10
-5
0
5
10

Back

Teachers' notes

Lesson notes

Subject	Physics 20
Topic	Dynamics
Title	Newton's 2nd Law
Grade(s)	11
Prior knowledge	Science 10, Unit B
Intended learning outcome(s)	Physics 20, Outcome B1.3k

Note: This lesson uses remote response technologies.

Teachers' notes

Lesson notes

Back

Students bring several alternative conceptions to their understanding of force. Most typically, they believe that:

A force "is carried" with an object after it has been released.
e.g. The force applied to a dynamics car continues to travel with the cart after it has been revealed.

An object needs to have a net force applied to it in order to continue with uniform motion.
e.g. A car experiences a net, non-zero force in travelling at a constant velocity.

Activity: Bean bags and Theraband (or "How I got in trouble with the administration")

Design: One person sits on a cart with a stack of pucks. Their job is to drop one bean bag off the cart every 2.0 s.

The job of the 2nd person is to pull the cart with the stretchy theraband. Their job is to keep the "amount of stretch" in the band constant as they pull the cart. A piece of fixed string helps with keeping the amount of stretch constant.

Theraband, carts, and bean bags....oh my!

Grade: 11

Subject: Physics 20

Date:

1 If the theraband remains stretched by the same amount while pulling the cart, then a constant force has been applied to the cart.

True

False

2 What pattern will the bean bags make on the floor?

A The bean bags will be evenly spaced.

B The bean bags will get farther and farther apart, and then be evenly spaced.

C The bean bags will be farther and farther apart.

OK...Let's go on a field trip to test this out.

To the hallway!

F

What is the result of applying an unbalanced force? (i.e. What happens when the total force acting on an object is non-zero?)

Cause Effect

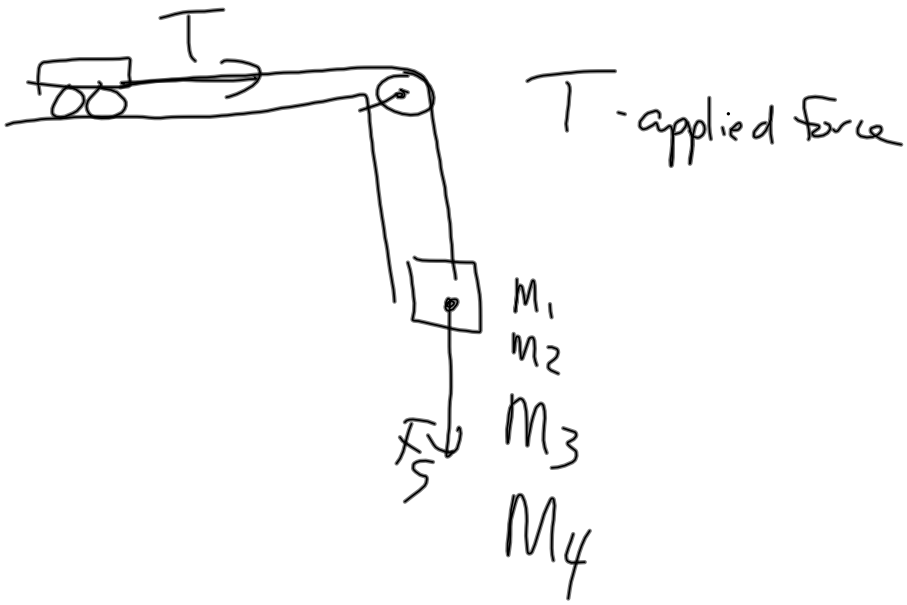
Applying an unbalanced force...
...causes accelerated motion.

Activity: Masses hooked to an air cart

Design: A hanging mass is attached to an air track cart with a string that is directed over a pulley. The motion of the cart is measured with a motion sensor.

The activity is repeated with heavier masses.

Control: the mass of the air cart



Air cart and hanging mass

Grade: 11

Subject: Physics 20

Date:

1 If we hang heavier masses on the string, then the force exerted on the cart...

A remains the same.

B gets larger.

C gets smaller.

OK...Let's try this out.

To the lab bench!

We know from before that unbalanced forces cause acceleration.

What is the relationship between the force applied and the acceleration?

$a \propto F$

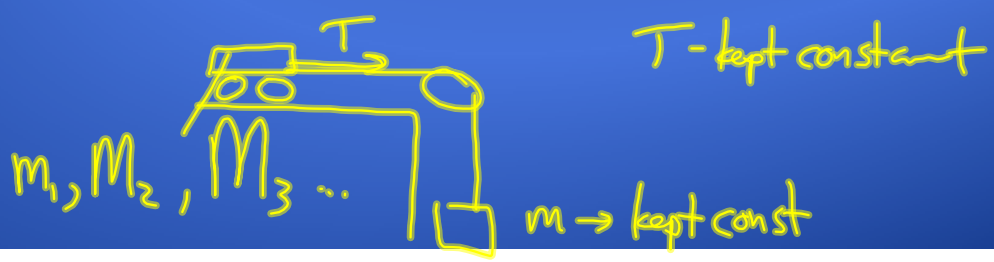
$\propto$ this means "related to"

in other words a is directly proportional to F

Let's try this again...

Design: This time we'll keep the hanging mass the same. We'll add more and more mass to the air cart.

Control: the hanging mass



$$a \propto \frac{1}{m}$$

Hanging mass and air cart

Grade: 11

Subject: Physics 20

Date:

1 What will happen as we add more mass to the air cart?

A The acceleration will not change.

B The acceleration will be greater.

C The acceleration will be less.

Let's put it all together...

Newton's 2nd Law of Motion:

When a unbalanced force non-zero net force acts on an object, the objec accelerates in the direction of the force.

The magnitude of the acceleration is directly proportional to the force, and indirectly proportional t the mass of the object.

$$\vec{F}_{net} = m\vec{a}$$

What units do we use?

$$\vec{F} = m\,\vec{a}$$

$$(N) = kg\,m/s^2$$

SI has base units like kg, m, and s (i.e. they can't be reduced). A N is not a base unit.

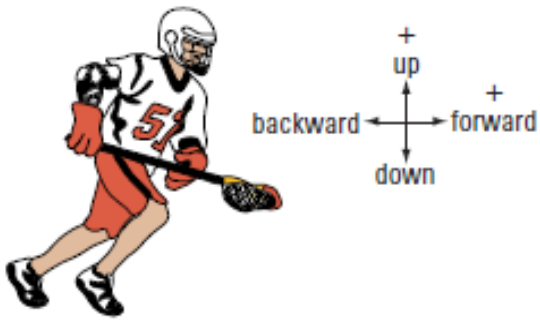
As part of our problem solving method with force, we're going to draw free-body-diagrams (FBDs). In a FBD we draw the object as a dot, and draw all the forces acting on the object as labelled arrows coming out of the dot.

Note: We're not going to draw all the forces for now...just the relevant ones.

Example 3.5

p. 149

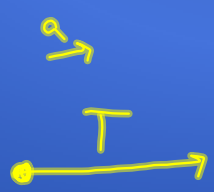
A lacrosse player exerts an average net horizontal force of 2.8 N [forward] on a 0.14-kg lacrosse ball while running with it in the net of his stick (Figure 3.36). Calculate the average horizontal acceleration of the ball while in contact with the lacrosse net.



T = 2.8 N (forward)

m = 0.14 kg

a = ?



T - applied force

$F_{net} = T$

$ma = T$

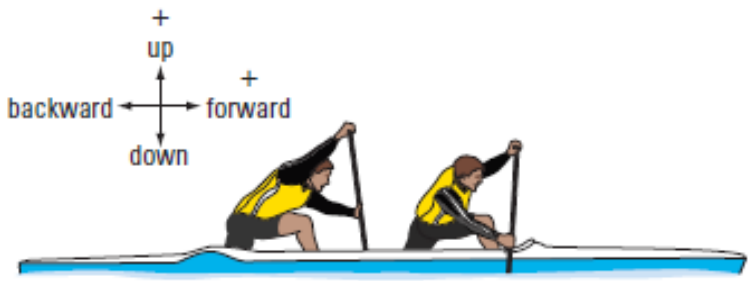
$a = \frac{T}{m}$

$a = \frac{2.8\,N}{0.14\,kg}$

$a = 20\ m/s^2$

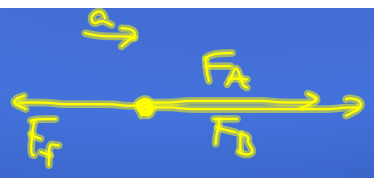
Example 3.6 p. 150

Two athletes on a team, A and B, are practising to compete in a canoe race (Figure 3.37). Athlete A has a mass of 70 kg, B a mass of 75 kg, and the canoe a mass of 20 kg. Athlete A can exert an average force of 400 N [forward] and B an average force of 420 N [forward] on the canoe using the paddles. During paddling, the magnitude of the water resistance on the canoe is 380 N. Calculate the initial acceleration of the canoe.



◀ Figure 3.37

$m_A = 70\,kg$
$m_B = 75\,kg$
$m_C = 20\,kg$
$F_A = 400\,N$ forward
$F_B = 420\,N$ forward
$F_f = 380\,N$
$a = ?$



$$F_{net} = F_A + F_B - F_f$$

$$ma = F_A + F_B - F_f$$

$$a = \frac{F_A + F_B - F_f}{m}$$

$$a = \frac{(400\,N) + (420\,N) - (380\,N)}{(70\,kg + 75\,kg + 20\,kg)}$$

$$a = 2.7\,m/s^2$$

Practice Problems: p. 149 #1,2

Practice Problems: p. 150 #1

Check and Reflect: p. 158 ~~#1-9~~ 6,7,8

5a

$F_g = mg$

$F_{net} = ma$

1. In the men's four-man bobsled event in the Winter Olympics, the maximum mass of a bobsled with two riders, a pilot, and a brakeman is 630 kg (Figure 3.39).

▲ **Figure 3.39**

During a practice run, riders A and B exert average forces of 1220 N and 1200 N [forward] respectively to accelerate a bobsled of mass 255 kg, a pilot of mass 98 kg, and a brakeman of mass 97 kg. Then they jump in for the challenging ride down a 1300-m course. During the pushing, the magnitude of the force of friction acting on the bobsled is 430 N. Calculate the average acceleration of the bobsled, pilot, and brakeman.

$F_A = 1220\,N$

$F_B = 1200\,N$

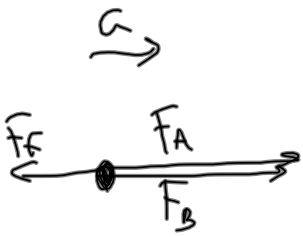
$m_s = 255\,kg$

$m_p = 98\,kg$

$m_b = 97\,kg$

$F_f = 430\,N$

$a = ?$



$$F_{net} = F_A + F_B - F_f$$

$$F_{net} = ma$$

$$\frac{\cancel{m}a}{\cancel{m}} = \frac{F_A + F_B - F_f}{m}$$

$$a = \frac{(1220\,N + 1200\,N - 430\,N)}{(255\,kg + 98\,kg + 97\,kg)}$$

$$a = 4.4\,m/s^2$$

7. Suppose the only horizontal forces acting on a 20-N object on a smooth table are 36 N [45°] and 60 N [125°].

(a) What is the net force acting on the object?

(b) Calculate the acceleration of the object.

$F_g = 20N$

$F_g = mg$

a) $F_{net} = ?$

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$

$F_x = (36N)\cos 45° + (60N)\cos 125° = -8.96N$

$F_y = (36N)\sin 45° + (60N)\sin 125° = +74.6N$

mag

$F_{net}^2 = (8.96N)^2 + (74.6N)^2$

$F_{net} = 75N$

dir

$\tan\theta = \frac{74.6}{8.96}$

$\theta = 83°$ N of W

b) $a = ?$

$F_{net} = ma$

$a = \frac{F_{net}}{m}$

$a = \frac{75N}{2.04kg}$

$a = 37 \, m/s^2$

$m = ?$

$F_g = mg$

$m = \frac{F_g}{g}$

$m = \frac{20N}{9.81 m/s^2}$

$m = 2.04kg$

* $F_{net} \Rightarrow ma$

$F_g \Rightarrow mg$

6. An ice hut used for winter fishing is resting on a level patch of snow. The mass of the hut is 80 kg. A wind exerts a horizontal force of 205 N on the hut, and causes it to accelerate. While in motion, the magnitude of the force of friction acting on the hut is 196 N. What is the acceleration of the hut?

$m = 80\,kg$

$F_w = 205\,N$

$F_f = 196\,N$

$a = ?$

$F_{net} = F_w - F_f$

$ma = F_w - F_f$

$a = \frac{F_w - F_f}{m}$

$a = \frac{205\,N - 196\,N}{80\,kg}$

$a = 0.113\,m/s^2$

Applications

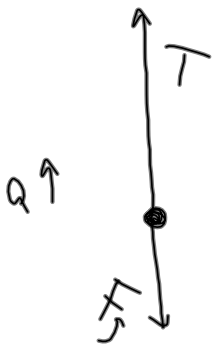
5. A dolphin experiences a force of 320 N [up] when it jumps out of the water. The acceleration of the dolphin is 2.6 m/s² [up].

(a) Calculate the mass of the dolphin.

$T = 320\,N$

$a = 2.6\,m/s^2$

$m = ?$



$F_{net} = T - F_g$

$ma = T \cancel{-mg}$

$+mg \quad \cancel{+mg}$

$ma + mg = T$

$m(a+g) = T$

$m = \frac{T}{a+g}$

$m = \frac{320\,N}{2.6\,m/s^2 + 9.81\,m/s^2}$

$m = 26\,kg$

$\frac{3x + 5x}{x(3+5)} = 16$

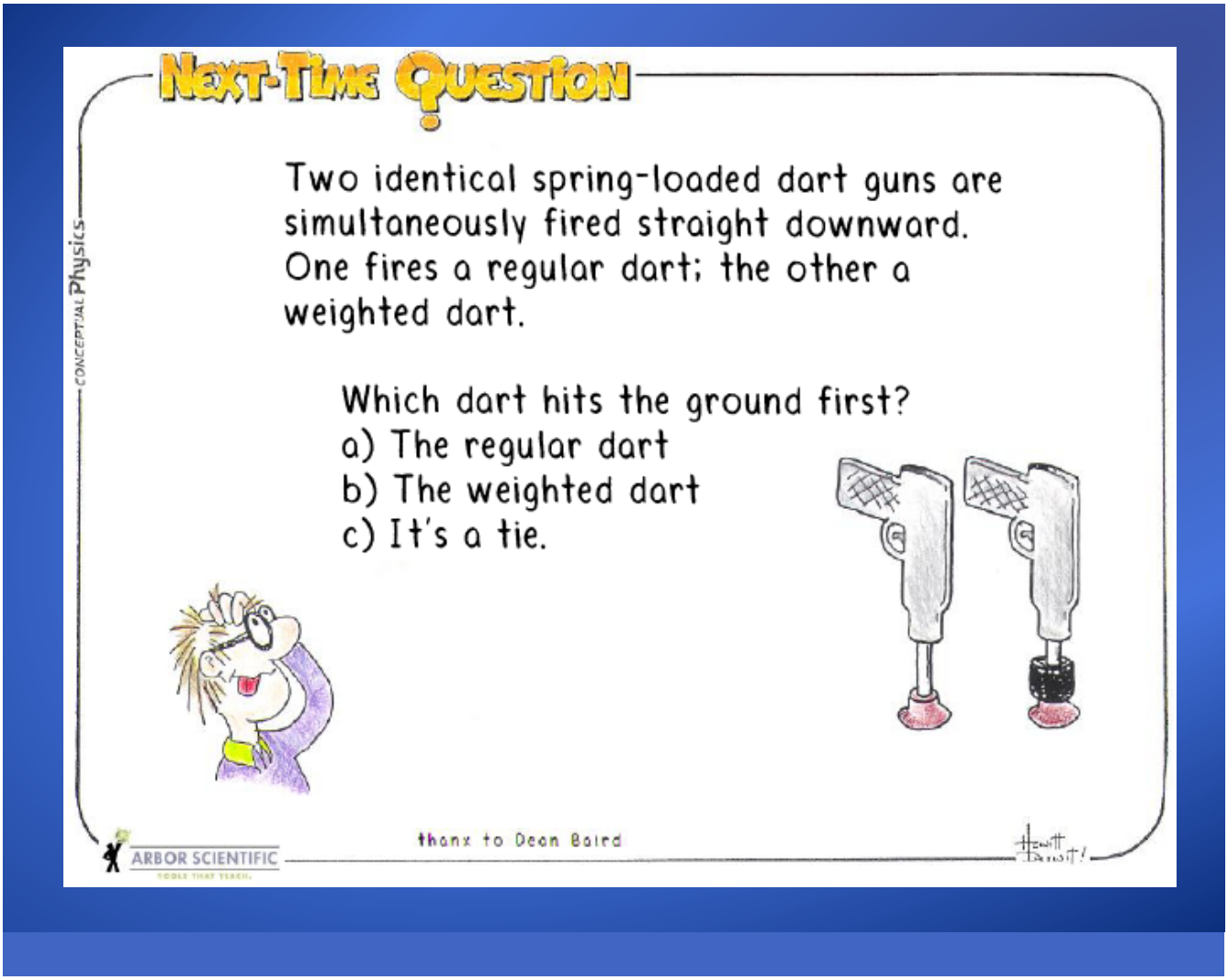
$8x$

Dart gun question

Grade: 11

Subject: Physics 20

Date:


NEXT-TIME QUESTION
Two identical spring-loaded dart guns are simultaneously fired straight downward. One fires a regular dart; the other a weighted dart.
Which dart hits the ground first?
a) The regular dart
b) The weighted dart
c) It's a tie.
thanx to Dean Baird
CONCEPTUAL Physics
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Next-Time Question

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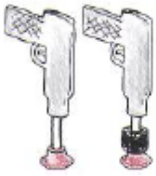

Answer: a
The springs in both guns apply the same amount of force to the darts, but the regular dart has less inertia and therefore has greater acceleration in the gun. So it emerges with a greater speed and wins the race!

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