Newtonian Dynamics

I. NEWTON’S 1ST LAW

“An object at rest shall remain at rest,

while an object in motion will remain in motion,

at the same speed, and in the same direction,

unless acted on by a ***net, external*** force.”

This can be stated a bit more concisely with some more modern language:

“All objects (with mass) move at constant velocity unless acted upon by an ***unbalanced external*** force.”

OR

“The natural state of motion for massive objects is constant velocity.”

OR

“If velocity is constant, the forces on an object must be balanced AND if the forces balance, velocity must be constant.”

OR

Zero Acceleration Balanced Forces EQUILIBRIUM

For the following situations, decide whether a net force is acting on the object. If a net force is acting, identify the force or forces responsible for the change in motion. The object we are considering are written in **bold**. If you think there is a net force, what is it? If there is no net force, what forces are balanced to keep the object in equilibrium?

1. The **Earth** is orbiting around the Sun.

2. The **Moon** is orbiting around the Earth.

3. A **car** drives straight down the highway at 100km/h.

4. A **car** travels around a circular track at 100km/h.

5. You fire a **clown** out of a cannon and he follows a parabolic trajectory through space.

6. Your **cat** gets scared and jumps straight up into the air!

7. A **junior executive** rides an elevator upward at 4.0m/s.

8. A **helicopter** is hovering above the Earth

9. You drop a **cat** and it falls to the ground. Don’t worry, it was just from waist-high. The cat is fine.

10.A **hockey puck** slide across the ice at 12m/s.

11. You lift a **book** straight up at constant speed.

12. A **skateboarder** rolls from the top a hill picking up speed as she goes.

For the following, each object is in EQUILIBRIUM. Try to find the missing force. Diagrams are not drawn to scale.

F2

41N

23N

8.0N

F1

6.0N

II. NEWTON’S 2ND LAW

“Unbalanced external forces result in acceleration.

The magnitude of the acceleration is reciprocally proportional to the mass.”

OR

“If an object of mass *m* experiences a net external force $\sum\_{}^{}\rightharpoonaccent{F}$, it will accelerate in the same direction as $\sum\_{}^{}\rightharpoonaccent{F}$

with an acceleration $\rightharpoonaccent{a}$= $\sum\_{}^{}\rightharpoonaccent{F}$/ *m*.”

OR

$$\sum\_{}^{}\rightharpoonaccent{F}=m\rightharpoonaccent{a}$$

1. You push a toddler in a stroller, accelerating her at 0.5 m/s2. The mass of the toddler and stroller are 35 kg. What net force (in Newtons, where 1 N = 1 kg·m/s2) acts on the stroller?

2. You push a toddler in a stroller, accelerating her at 3.0m/s2 East . The mass of the toddler and stroller are 25 kg. What net force (in Newtons, where1 N $≡$ 1kg·m/s2) is acting on the stroller? If the force of friction acting between the stroller and the ground is 35N West, what force must you apply?

3. A 10.0kg object experiences two simultaneous forces. $\rightharpoonaccent{F}\_{1}$= 3.0N $\hat{y}$ and $\rightharpoonaccent{F}\_{2}$= 4.0N $\hat{x}. $Find the acceleration of this object.

4. A 25 kg bag of phlegm and sriracha, in a 3:8 ratio, sits on a table at rest. (a) What is the acceleration, $\rightharpoonaccent{a}$,of this disgusting bag? (b) What is the net force acting on this gross bag? (c) Draw a free body diagram for the revolting bag. (d) What are the magnitude (in Newtons) and direction of the normal force, $\rightharpoonaccent{F}\_{N}$, acting on this spicy abomination?

5. You push a brick along horizontal table with a force $\rightharpoonaccent{F}$push of 50N $\hat{x}$. The brick experiences a frictional force $\rightharpoonaccent{F}$friction of -10N $\hat{x}$. (a) Draw a free body diagram for the brick. (b) What is the net force $\sum\_{}^{}\rightharpoonaccent{F}$on the brick?

(c) If the brick has a mass of 2 kg, what is its acceleration, $\rightharpoonaccent{a}$?

6. The 12kg mass shown below is accelerating to the left at 2.0m/s2. Find F1.

 86N 234N

 F1

7. Find the acceleration of the 13kg mass shown below.

 26N

 67N 73N

 22N

 17N

8. Find the acceleration of the 2350kg object shown below.

23o

41o

3212N

2650N

III. NEWTON’S 3RD LAW

“For every action there is an

equal and opposite reaction”

OR

“All forces come in pairs. Each force in a pair is of the same type and acts on a separate

object. The two forces are equal in magnitude and opposite in direction.”

OR

“If **OBJECT A** applies a force (action) to *OBJECT B*, *OBJECT B* applies force (reaction) to **OBJECT A**.

These forces are of the same type, have the same magnitude and are in opposite directions.”

OR

“If A pushes B, B pushes A.”

For the following situation, identify the 3rd law force pairs on the associated free body diagrams. Label each member of one pair “A”, each member of the next pair “B” and so on. Also label each free body diagram to identify each object (Block o’ Wood, Earth, Wall)

FN

Block o’ Wood

Fspring

Fspring

Ff

Fg

Ff

Fg

FN

Draw free body diagrams for the situation below. The spring has been stretched to the left, past is natural length, marked 0. The blocks accelerate to the right together, i.e. the top block does NOT slip off of the bottom block. There is friction between the bottom block and the ground. After you have drawn your FBDs, identify the 3rd law force pairs, as above.

Block o’ Wood

Lil’ Fella

 Top Block:

 Bottom Block:

 0

 Wall:

 Earth:

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Zero Acceleration Balanced Forces EQUILIBRIUM

For the following situations, decide whether a net force is acting on the object. If a net force is acting, identify the force or forces responsible for the change in motion. The object we are considering are written in **bold**. If you think there is a net force, what is it? If there is no net force, what forces are balanced to keep the object in equilibrium?

1. The **Earth** is orbiting around the Sun. Net force is GRAVITY

2. The **Moon** is orbiting around the Earth. Net force is GRAVITY

3. A **car** drives straight down the highway at 100km/h. Zero net force. Fengine balances Fresistance (wind, friction…)

4. A **car** travels around a circular track at 100km/h. Net force is FRICTION

5. You fire a **clown** out of a cannon and he follows a parabolic trajectory through space. Net force is GRAVITY

6. Your **cat** gets scared and jumps straight up into the air! Net force is (FLOOR - FRICTION)

7. A **junior executive** rides an elevator upward at 4.0m/s. Zero net force. Felevator=Fgravity

8. A **helicopter** is hovering above the Earth Zero net force. Flift=Fgravity

9. You drop a **cat** and it falls to the ground. Don’t worry, it was just from waist-high. The cat is fine. Net force is GRAVITY

10.A **hockey puck** slides across the ice at 12m/s. Zero net force. Gravity balances the force from the ice.

11. You lift a **book** straight up at constant speed. Zero net force. Fyou=Fgravity

12. A **skateboarder** rolls from the top a hill picking up speed as she goes. Net force is GRAVITY

For the following, each object is in EQUILIBRIUM. Try to find the missing force. Diagrams are not drawn to scale.

1.0x10N [37o above +x]

41N

23N

8.0N

18N

6.0N

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with an acceleration $\rightharpoonaccent{a}$= $\sum\_{}^{}\rightharpoonaccent{F}$/ *m*.”

OR

$$\sum\_{}^{}\rightharpoonaccent{F}=m\rightharpoonaccent{a}$$

1. You push a toddler in a stroller, accelerating her at 0.5 m/s2. The mass of the toddler and stroller are 35 kg. What net force (in Newtons, where 1 N = 1 kg·m/s2) acts on the stroller? 20N (17.5N)

2. You push a toddler in a stroller, accelerating her at 3.0m/s2 East . The mass of the toddler and stroller are 25 kg. What net force (in Newtons, where1 N $≡$ 1kg·m/s2) is acting on the stroller? If the force of friction acting between the stroller and the ground is 35N West, what force must you apply? Fnet=75N East, Fyou=110N East

3. A 10.0kg object experiences two simultaneous forces. $\rightharpoonaccent{F}\_{1}$= 3.0N $\hat{y}$ and $\rightharpoonaccent{F}\_{2}$= 4.0N $\hat{x}. $Find the acceleration of this object. 0.50m/s2 [53o above +x]

4. A 25 kg bag of phlegm and sriracha, in a 3:8 ratio, sits on a table at rest. (a) What is the acceleration, $\rightharpoonaccent{a}$,of this disgusting bag? (b) What is the net force acting on this gross bag? (c) Draw a free body diagram for the revolting bag. (d) What are the magnitude (in Newtons) and direction of the normal force, $\rightharpoonaccent{F}\_{N}$, acting on this spicy abomination? (a) 0m/s2 (b) 0N (c) FN (d) 250N up (245N)

 Fg

5. You push a brick along horizontal table with a force $\rightharpoonaccent{F}$push of 50N $\hat{x}$. The brick experiences a frictional force $\rightharpoonaccent{F}$friction of -10N $\hat{x}$. (a) Draw a free body diagram for the brick. (b) What is the net force $\sum\_{}^{}\rightharpoonaccent{F}$on the brick?

FN

(c) If the brick has a mass of 2 kg, what is its acceleration, $\rightharpoonaccent{a}$? (b) 40N $\hat{x}$ (c) 20m/s2 $\hat{x}$ (a)

50N

10N

6. The 12kg mass shown below is accelerating to the left at 2.0m/s2. Find F1.

mg

 86N 234N

 172N = F1

7. Find the acceleration of the 13kg mass shown below.

 26N

ay=0.692307692m/s2 up

ax=2.153846154m/s2 right

 67N 73N

 22N

$\rightharpoonaccent{a}$ = 2.3m/s2 [18o abnove +x] 17N

8. Find the acceleration of the 2350kg object shown below.

23o

41o

3212N

2650N

$\rightharpoonaccent{a}\_{x}=$0.407098383m/s2 right

$\rightharpoonaccent{a}\_{y}=$1.273865877m/s2 down

$\rightharpoonaccent{a}$ = 1.3m/s2 [72o below +x]

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FNA

Block o’ Wood

FspringB

FspringA

FfA

 Wall

FgB

 Wood

FgA

FfB

 Earth

FNB

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Block o’ Wood

Lil’ Fella

 Top Block:

 Bottom Block:

 0

 Wall:

 Earth: