DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS
IB PHYSICS

TSOKOS LESSON 2-2B
NEWTON’S SECOND LAW

Reading Activity Questions?

Essential Idea:

- Classical physics requires a force to change a state of motion, as suggested by Newton in his laws of motion.

Nature Of Science:

- Using mathematics: Isaac Newton provided the basis for much of our understanding of forces and motion by formalizing the previous work of scientists through the application of mathematics by inventing calculus to assist with this. (2.4)

Nature Of Science:

- Intuition: The tale of the falling apple describes simply one of the many flashes of intuition that went into the publication of Philosophiæ Naturalis Principia Mathematica in 1687. (1.5)

Theory Of Knowledge:

- Classical physics believed that the whole of the future of the universe could be predicted from knowledge of the present state.
- To what extent can knowledge of the present give us knowledge of the future?

Understandings:

- Objects as point particles
- Free-body diagrams
- Translational equilibrium
- Newton’s laws of motion
- Solid friction

Applications And Skills:

- Representing forces as vectors
- Sketching and interpreting free-body diagrams
- Describing the consequences of Newton’s first law for translational equilibrium
- Using Newton’s second law quantitatively and qualitatively

Applications And Skills:

- Identifying force pairs in the context of Newton's third law
- Solving problems involving forces and determining resultant force
- Describing solid friction (static and dynamic) by coefficients of friction

Guidance:

- Students should label forces using commonly accepted names or symbols (for example: weight or force of gravity or mg)
- Free-body diagrams should show scaled vector lengths acting from the point of application

Guidance:

- Examples and questions will be limited to constant mass
- mg should be identified as weight
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Data Booklet Reference:

$$F = ma$$

$$F_f \leq \mu_s R$$

$$F_f = \mu_d R$$

Utilization:

- Motion of charged particles in fields (see Physics sub-topics 5.4, 6.1, 11.1, 12.2)
- Application of friction in circular motion (see Physics sub-topic 6.1)
- Construction (considering ancient and modern approaches to safety, longevity and consideration of local weather and geological influences)
- Biomechanics (see Sports, exercise and health science SL sub-topic 4.3)

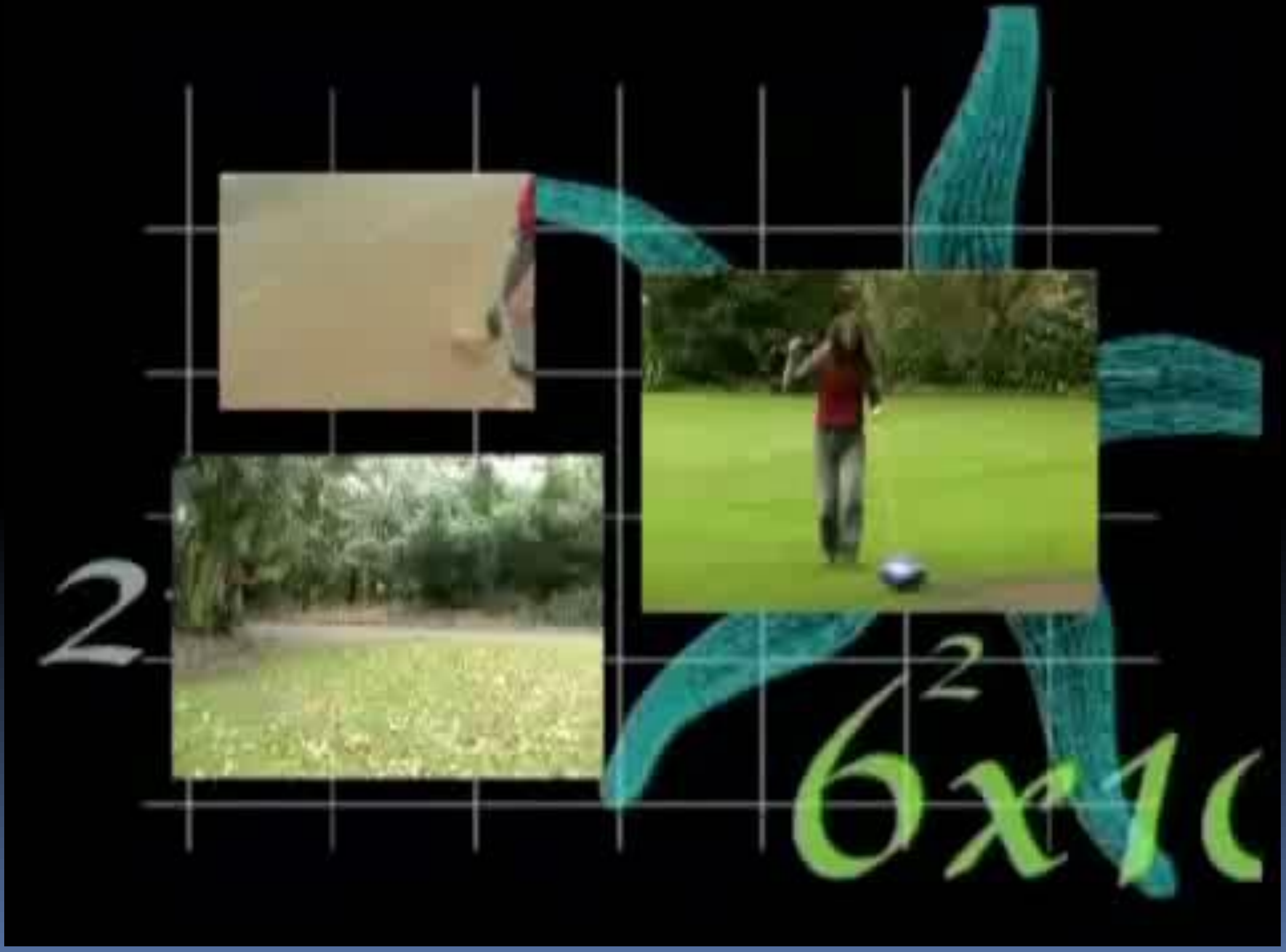
Aims:

- **Aims 2 and 3:** Newton's work is often described by the quote from a letter he wrote to his rival, Robert Hooke, 11 years before the publication of *Philosophiæ Naturalis Principia Mathematica*, which states: "*What Descartes did was a good step. You have added much several ways, and especially in taking the colours of thin plates into philosophical consideration. If I have seen a little further it is by standing on the shoulders of Giants.*" It should be remembered that this quote is also inspired, this time by writers who had been using versions of it for at least 500 years before Newton's time.

Aims:

- **Aim 6:** experiments could include (but are not limited to): verification of Newton's second law; investigating forces in equilibrium; determination of the effects of friction

Video: Newton's Second Law of Motion



Newton's Second Law

- The ***net*** force on a body is proportional to that body's acceleration and is in the ***same direction*** as the acceleration

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

where *m* is mass, the constant of proportionality

Newton's Second Law

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

- The unit of force is the Newton (N)
  - 1N = 1kg•m/s^2
  - ma = (kg)(m/s^2)
- Weight is a force caused by gravitational attraction

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

$$a = g$$

Newton’s Second Law

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

- ***When you jump from the emergency exit after the fire alarm goes off because of Mr. Lawhead’s smoke machine, how do you minimize the bone-crushing force on your body?***

Newton's Second Law

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

- *When you jump from the emergency exit after the fire alarm goes off because of Mr. Lawhead's smoke machine, how do you minimize the bone-crushing force on your body?*
- *You bend your knees to decrease the deceleration and execute a parachute landing fall to translate vertical acceleration into rotational acceleration.*

Newton's Second Law

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

- ***How do car manufacturers try to minimize the forces absorbed by passengers during a collision?***

Newton's Second Law

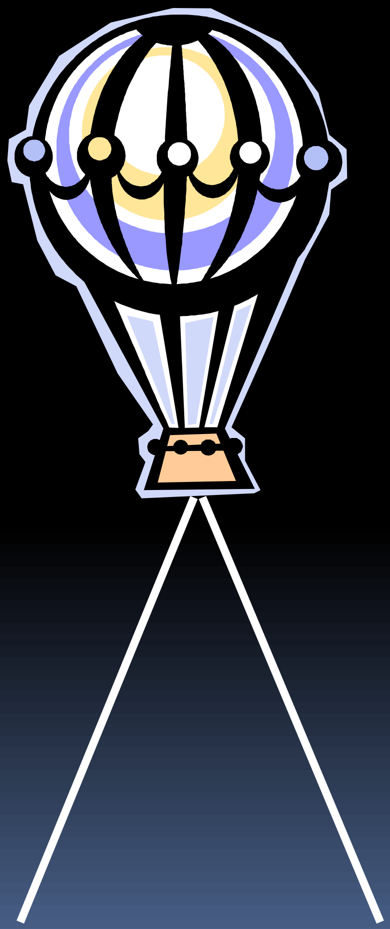
$$\vec{F} = m\vec{a}$$

- *How do car manufacturers try to minimize the forces absorbed by passengers during a collision?*
- *Air bags and crumple zones.*

Newton's Second Law Sample Problem

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

- ***A 200-kg hot air balloon is held to the ground by two wires that make a 60-degree angle to the ground. When the wires are released, the balloon accelerates upward at 3 m/s². What is the tension in each cable?***



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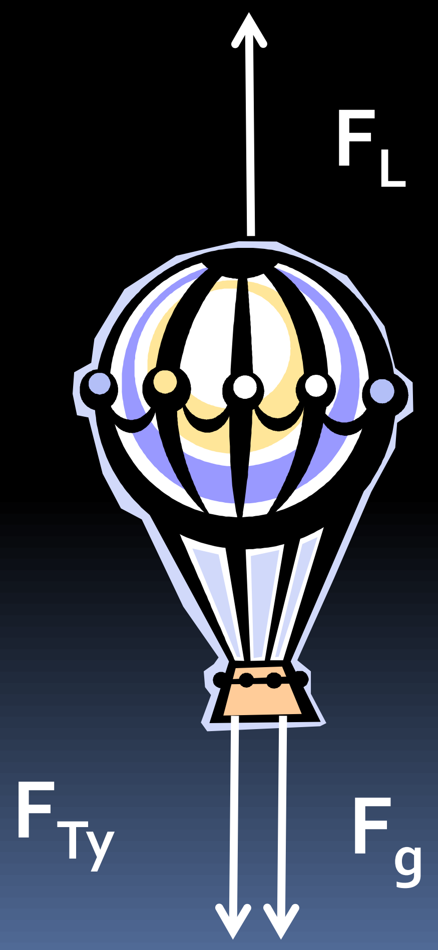

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$$\sum \vec{F} = m\vec{a}$$

$$F_L - F_g - F_{Ty} = 0$$

$$F_{Ty} = F_L - F_g$$

$$F_g = mg$$

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

$$F_L - F_g = ma$$

$$F_L = ma + mg$$

Newton's Second Law Sample Problem

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$$F_{Ty} = F_L - F_g$$

$$F_g = mg$$

$$F_L = ma + mg$$

$$F_{Ty} = ma + mg - mg$$

$$F_{Ty} = ma = 600N$$

Newton's Second Law Sample Problem

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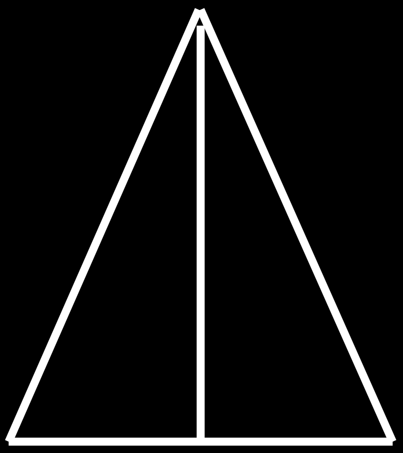

$$F_{Ty} = 600N$$

$$Sin60^\circ = \frac{F_{Ty}}{2F_T}$$

$$F_T = \frac{600N}{2Sin60^\circ}$$

$$F_T = 346N$$

Inclined Plane Problem

- ***A 150kg mass is placed on a plane inclined at a 17° angle. The coefficient of static friction is 0.30 and the coefficient of dynamic friction is 0.25. What happens?***

Fuzzy Dice Problem

- ***A pair of fuzzy dice hang from the rearview mirror of a car. The car accelerates from a stoplight at $2 m/s^2$. What happens?***

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QUESTIONS?

Homework

Pg 77-78, #47-54