HSC Physics
A review
Tips and tricks

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Physics High

- ★ Videos on all concepts in HSC
- ★ Review videos on all modules
- ★ Links to interactives and worksheets
- ★ "How well do you know' videos to test understanding

  using HSC style MC questions
- ★ HSC questions from 2010 onwards explained

www.physicshigh.com

also on Youtube

HSC Physics

Module 5 Advanced Mechanics

Projectile Motion
How can models that are used to explain projectile motion be used to analyse and make predictions?

Circular Motion
Why do objects move in circles?

Motion in Gravitational Fields
How does the force of gravity determine the motion of planets and satellites?

Module 6 Electromagnetism

Charged Particles, Conductors and Electric and Magnetic Fields
What happens to stationary and moving charged particles when they interact with an electric or magnetic field?

The Motor Effect
Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Electromagnetic Induction
How are electric and magnetic fields related?

Applications of the Motor Effect
How has knowledge about the Motor Effect been applied to technological advances?

Module 7 The Nature of Light

Electromagnetic Spectrum
What is light?

Light: Wave Model
What evidence supports the classical wave model of light and what predictions can be made using this model?

Light: Quantum Model
What evidence supports the particle model of light and what are the implications of this evidence for the development of the quantum model of light?

Light and Special Relativity
How does the behaviour of light affect concepts of time, space and matter?

Module 8 From the Universe to the Atom

Origins of the Elements
What evidence is there for the origins of the elements?

Structure of the Atom
How is it known that atoms are made up of protons, neutrons and electrons?

Deep inside the Atom
How is it known that human understanding of matter is still incomplete?

Properties of the Nucleus
How can the energy of the atomic nucleus be harnessed?

Quantum Mechanical Nature of the Atom
How is it known that classical physics cannot explain the properties of the atom?

Take home

- The inquiry question are key
- Try to answer them as practice

Module 5

Advanced Mechanics

3 inquiry questions

- How can models that are used to explain projectile motion be used to analyse and make predictions?
- Why do objects move in circles?
- How does the force of gravity determine the motion of planets and satellites?

How can models that are used to explain projectile motion be used to analyse and make predictions?

- What is projectile motion?

- How do we solve projectile problems

How can models that are used to explain projectile motion be used to analyse and make predictions?

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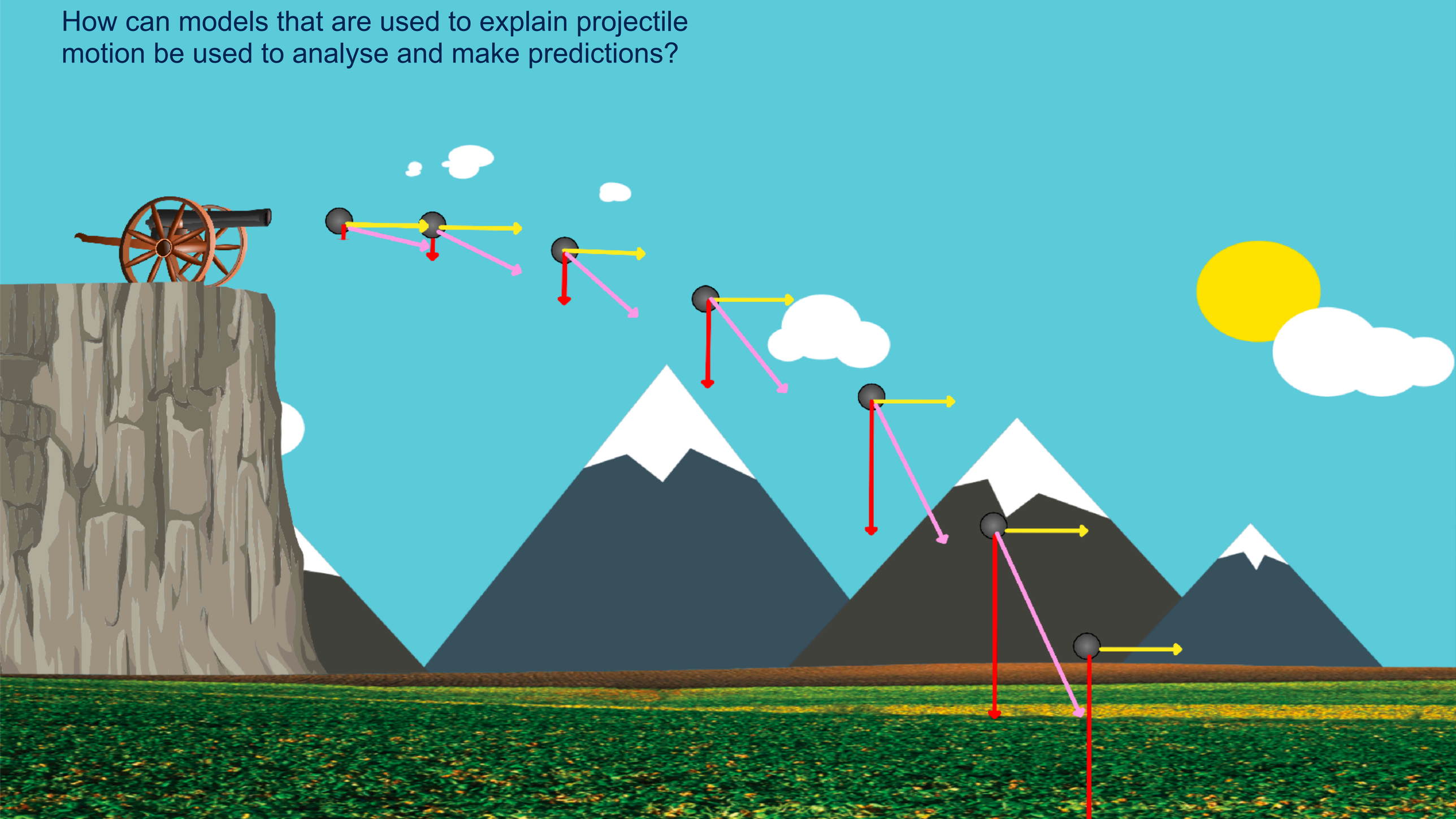
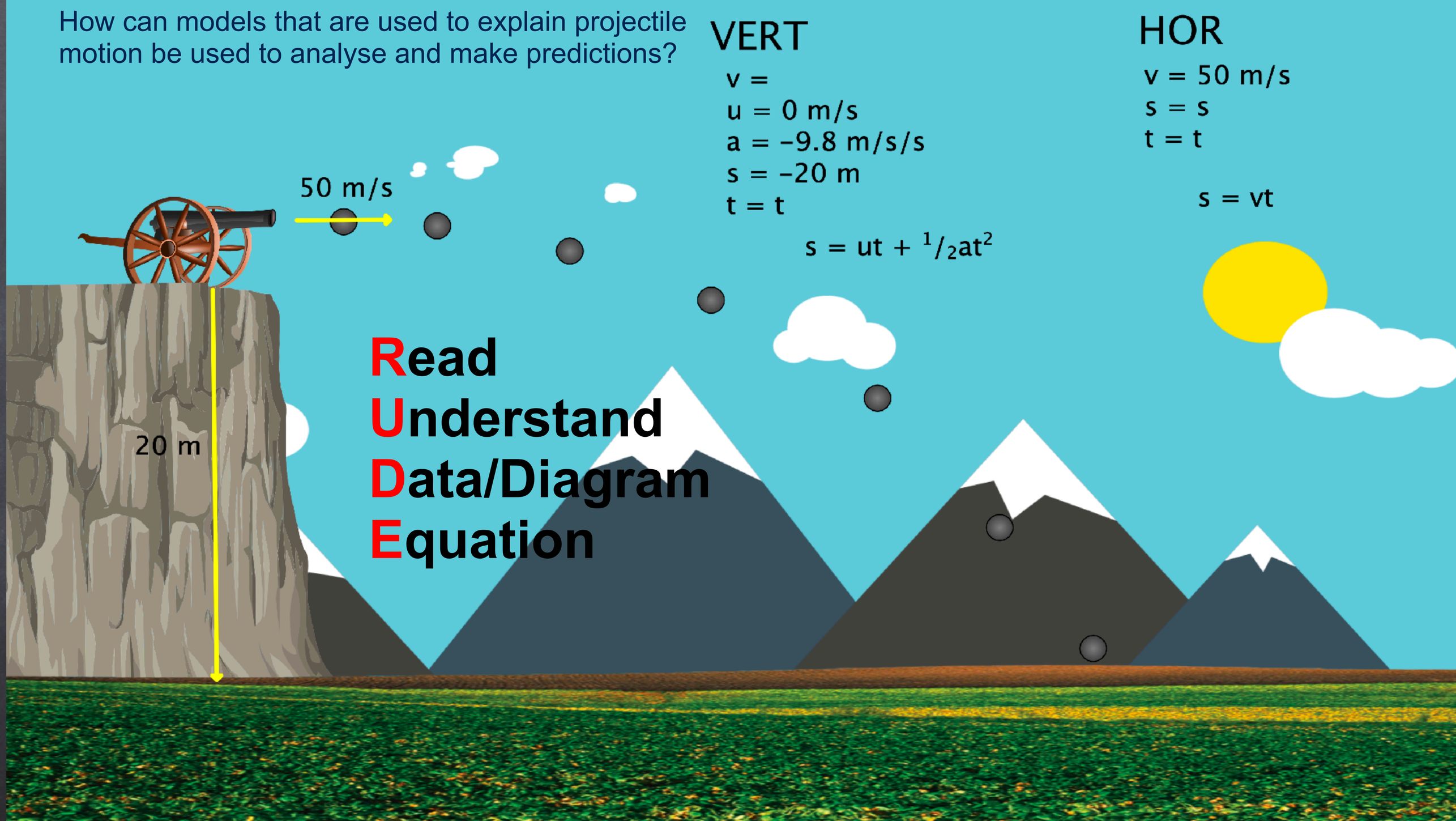


How can models that are used to explain projectile motion be used to analyse and make predictions?



Read
Understand
Data/Diagram
Equation

VERT

v =
u = 0 m/s
a = -9.8 m/s/s
s = -20 m
t = t

$s = ut + {}^{1}/_{2}at^{2}$

HOR

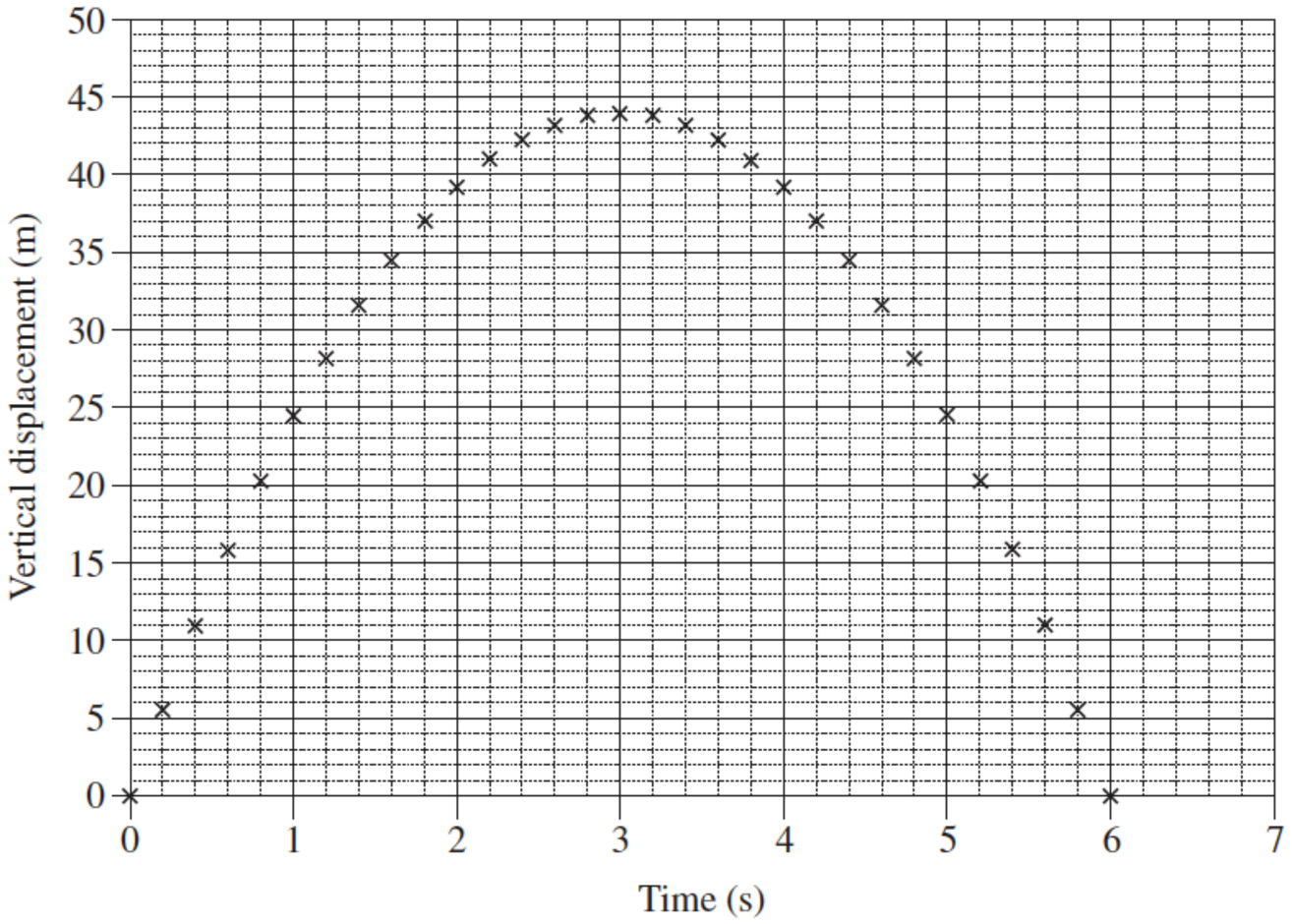
v = 50 m/s
s = s
t = t

$s = vt$

Question 24 2020

4 marks

The graph shows the vertical displacement of a projectile throughout its trajectory. The range of the projectile is 130 m.

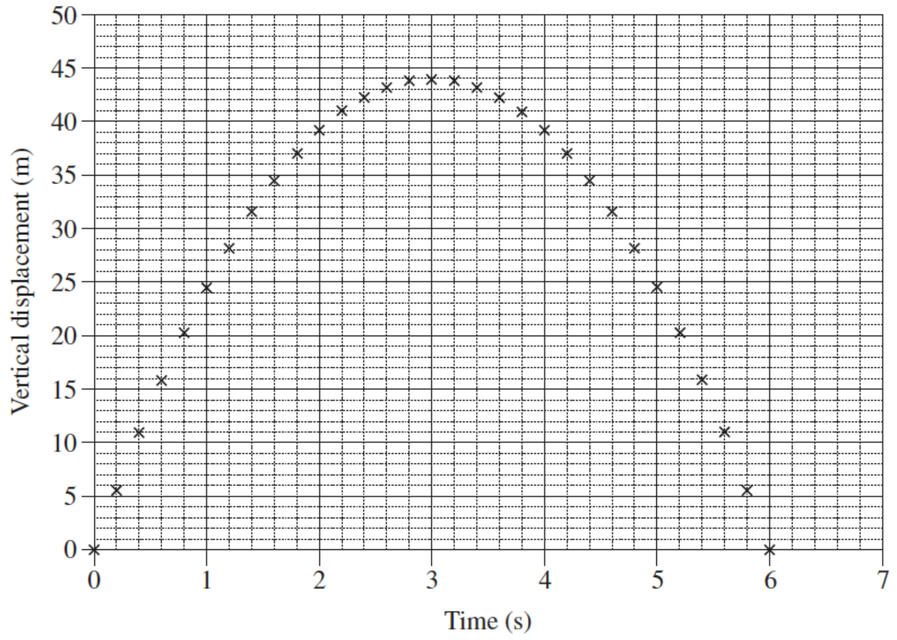


Calculate the initial velocity of the projectile.

Question 24 2020

4 marks

The graph shows the vertical displacement of a projectile throughout its trajectory. The range of the projectile is 130 m.



Calculate the initial velocity of the projectile.

Sample answer:

From the graph, max height is 44 m and $v_y = 0$ at max height. Therefore:

$$v_y^2 - u_y^2 + 2a_y s_y$$

$$0 = u_y^2 + 2 \times (-9.8) \times 44$$

$$u_y - 29.4 \text{ m s}^{-1}$$

From the graph, time of flight is 6s. Therefore:

$$u_x - \frac{s_x}{t} - \frac{130}{6} - 21.7 \text{ m s}^{-1}$$

Applying Pythagoras' relationship:

$$u^2 - u_x^2 + u_y^2$$

$$u^2 - 21.7^2 + 29.4^2$$

$$u = 36.5 \text{ m s}^{-1}$$

Calculating angle of launch:

$$\tan\theta = \frac{u_y}{u_x}$$

$$\theta - 54°$$

Therefore $u = 37 \text{ ms}^{-1}$, 54° above the horizontal.

Take home

- Question is about skills
- Set it out - be RUDE
- Sig dig

Criteria	Marks
• Correctly calculates the magnitude and direction of the initial velocity	4
• Provides the main steps for calculating the initial velocity	3
• Provides some steps for calculating the initial velocity	2
• Provides some relevant information	1

The typical performance in this band:

Band 6

- demonstrates an extensive knowledge and understanding of scientific concepts, including complex and abstract ideas
- communicates scientific understanding succinctly, logically, and consistently using correct and precise scientific terms and application of nomenclature in a variety of formats and wide range of contexts
- designs and plans investigations to obtain accurate, reliable, valid and relevant primary and secondary data, evaluating risks, mitigating where applicable, and making modifications in response to new evidence
- selects, processes, and interprets accurate, reliable, valid, and relevant qualitative and quantitative, primary or secondary data, and represents it using a range of scientific formats to derive trends, show patterns and relationships, explain phenomena, and make predictions
- designs solutions to scientific problems, questions, or hypotheses using selected accurate, reliable, valid, and relevant primary and secondary data, and scientific evidence, by applying processes, modelling and formats
- applies knowledge and information to unfamiliar situations to propose comprehensive solutions or explanations for scientific issues or scenarios

Band 5

- demonstrates thorough knowledge and understanding of scientific concepts, including complex and abstract ideas
- communicates scientific understanding, logically, and effectively using correct scientific terms and application of nomenclature in a variety of formats and wide range of contexts
- designs and plans investigations to obtain accurate, reliable, valid and relevant primary and secondary data, evaluating risks, mitigating where applicable, and making some modifications in response to new evidence
- selects, processes, and interprets accurate, reliable, valid, and relevant qualitative and quantitative, primary or secondary data, and represents it using a range of scientific formats to derive trends, show patterns and relationships
- designs solutions to scientific problems, questions, or hypotheses using selected accurate, reliable, and valid primary and secondary data, and scientific evidence, by applying processes, and formats
- applies knowledge and information to unfamiliar situations to propose explanations for scientific issues or scenarios

Band 4

- demonstrates sound knowledge and understanding of scientific concepts
- communicates scientific understanding effectively using scientific terms and application of nomenclature
- designs and plans investigations to obtain primary and secondary data and evaluates risks
- processes and interprets primary and secondary data, and represents it using a range of scientific formats
- identifies scientific problems, questions, or hypotheses and applies processes, and formats to primary or secondary data
- applies knowledge and information relevant to scientific issues or scenarios

Band 3

- demonstrates basic knowledge and understanding of scientific concepts
- communicates scientific understanding using basic scientific terms and application of nomenclature
- implements scientific processes to obtain primary and secondary data and identifies risks
- processes primary or secondary data, and represents it using scientific formats
- responds to scientific problems, questions, or hypotheses
- recalls scientific knowledge and information

Band 2

- demonstrates limited knowledge and understanding of scientific concepts
- communicates scientific understanding using limited scientific terms
- partially outlines investigations to obtain data and information
- provides simple descriptions of scientific phenomena
- recalls basic scientific knowledge and information

Band 1

Performance Band Descriptors for Physics

Processing information

Band 3

processes primary or secondary data, and represents it using scientific formats

Band 4

processes and interprets primary and secondary data, and represents it using a range of scientific formats

Band 5

selects, processes, and interprets accurate, reliable, valid, and relevant qualitative and quantitative, primary or secondary data, and represents it using a range of scientific formats to derive trends, show patterns and relationships

Band 6

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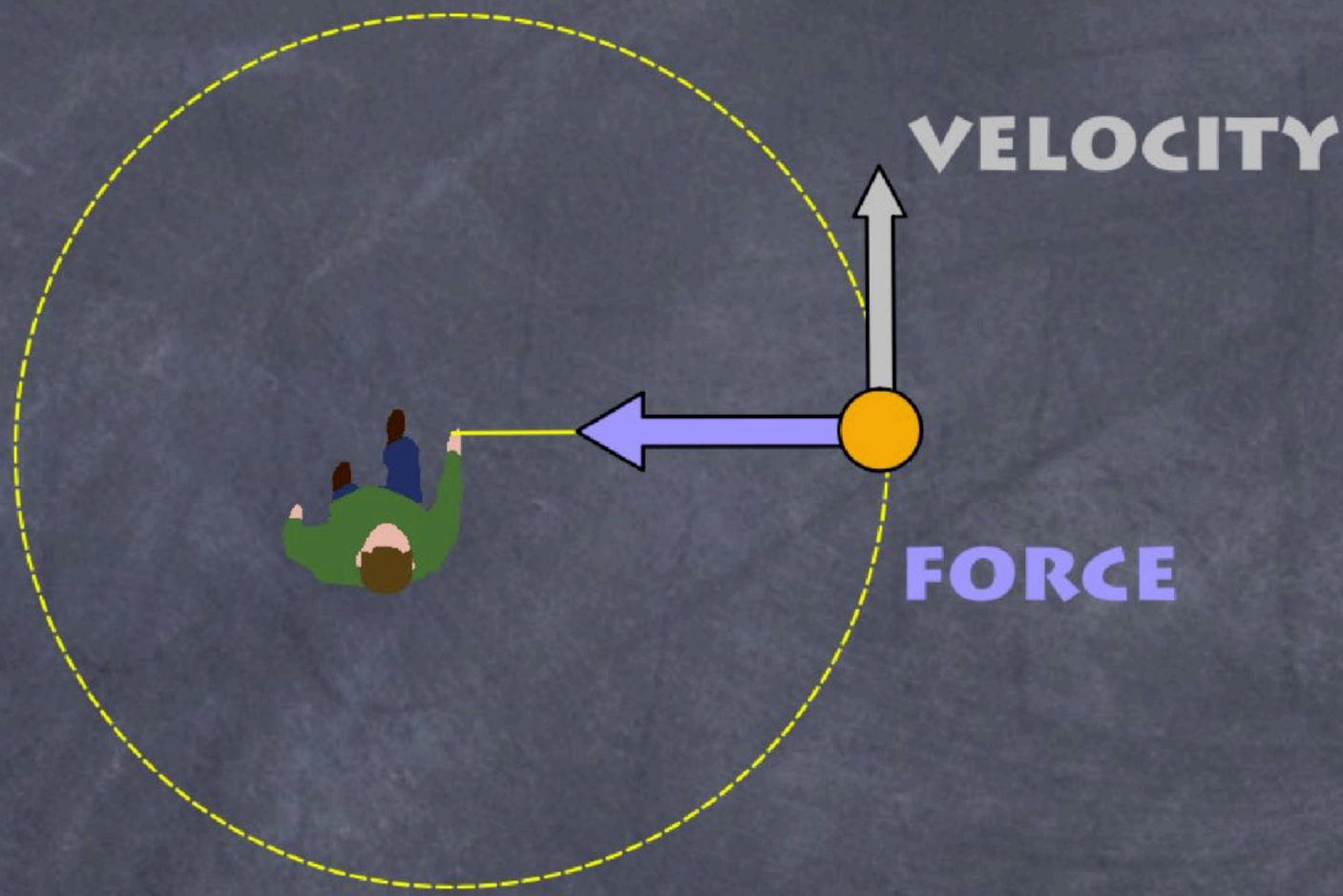
See "**How to Get a Band 6**" @

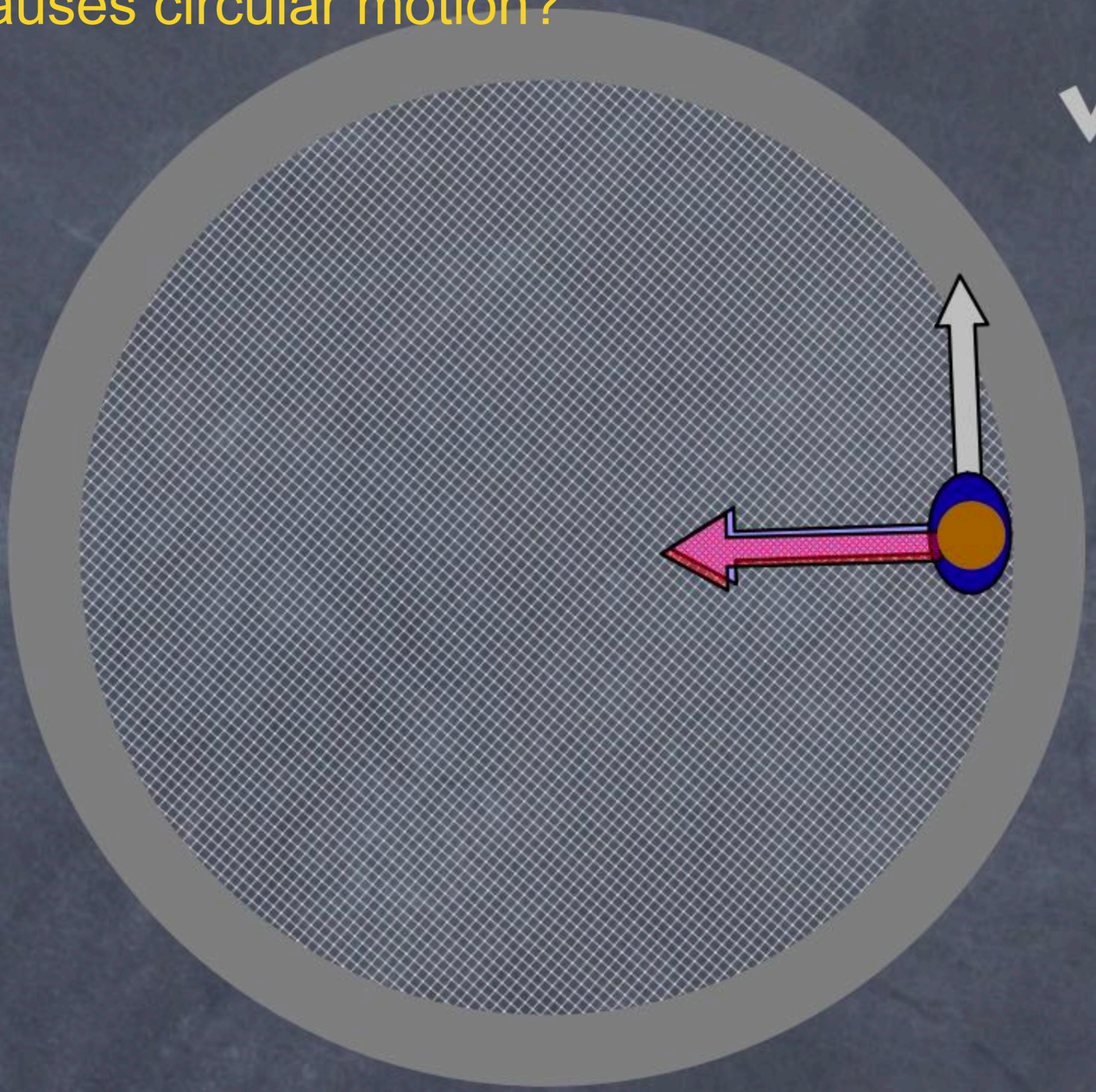
Why do objects move in circles?

- How do we define circular motion?
- What are the forces involved in circular motion?
- Solving circular motion problems
- Energy
- What is torque?

- What causes circular motion?



- What causes circular motion?

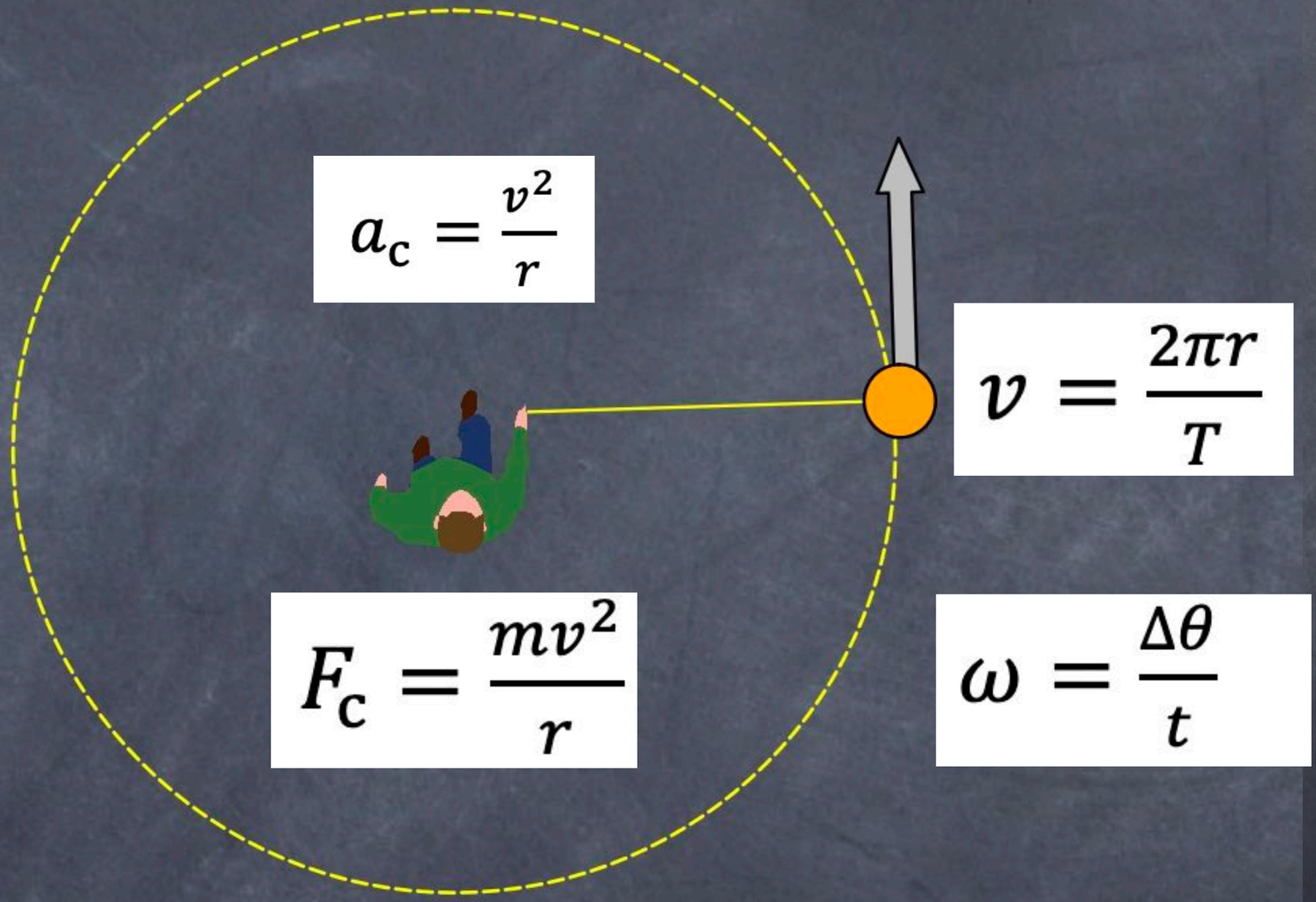


VELOCITY

FORCE

NORMAL

★ Solving circular motion problems



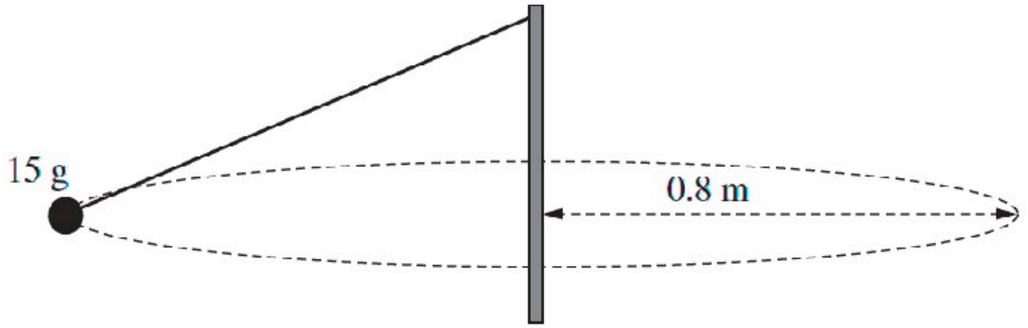
$$a_c = \frac{v^2}{r}$$

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

$$F_c = \frac{mv^2}{r}$$

$$\omega = \frac{\Delta\theta}{t}$$

A 15-gram metal ball bearing on a string is swung around a pole in a circle of radius 0.8 m. The plane of the circular path is horizontal. The angular velocity of the motion is 4π rad s^{-1}.



What is the magnitude of the centripetal force required to maintain the motion of the ball?

A. 0.7 N

B. 1.9 N

C. 2.4 N

D. 3.0 N

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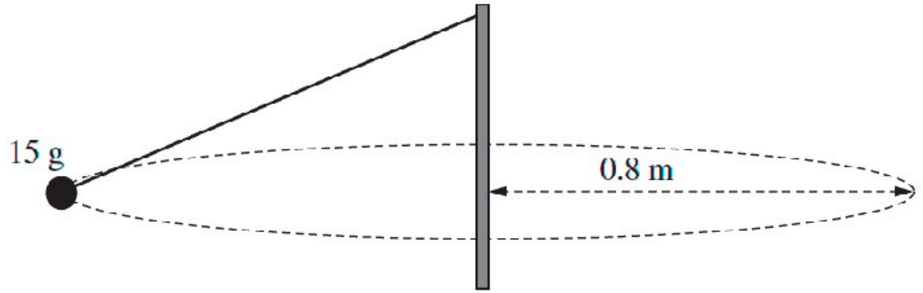


What is the magnitude of the centripetal force required to maintain the motion of the ball?

A. 0.7 N

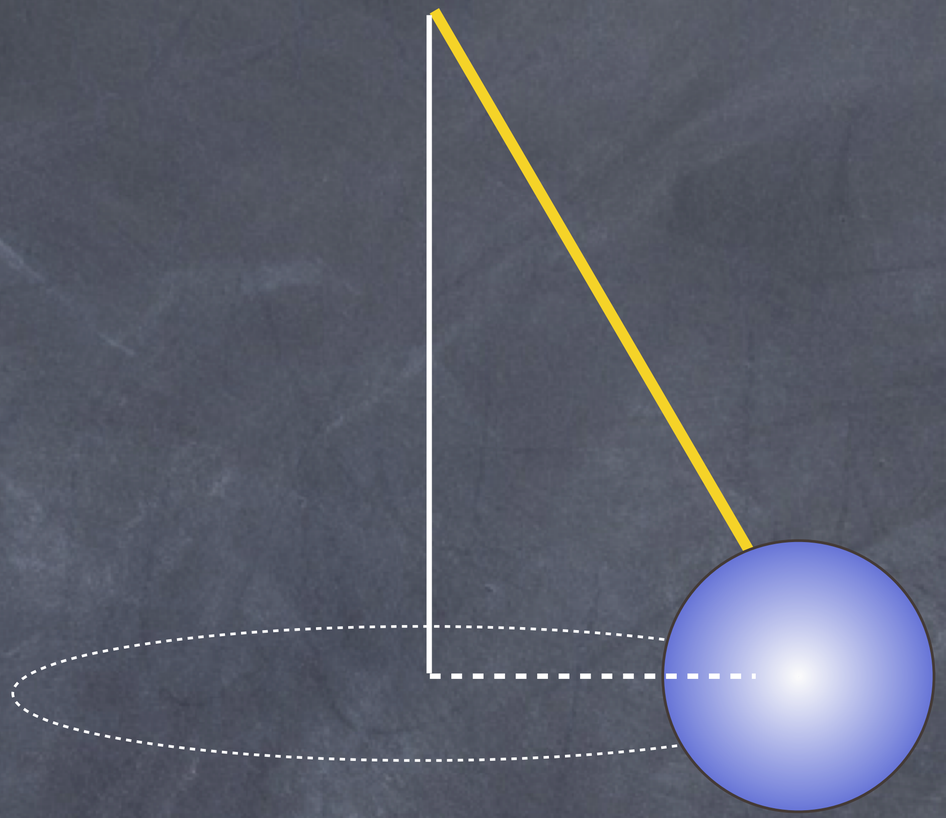
B. 1.9 N

C. 2.4 N

D. 3.0 N

$$F_c = \frac{mv^2}{r} = m\omega^2 r = (0.15)(4\pi)^2(0.8) = 1.89\ N$$

- What are the forces involved in circular motion?



Conical pendulum

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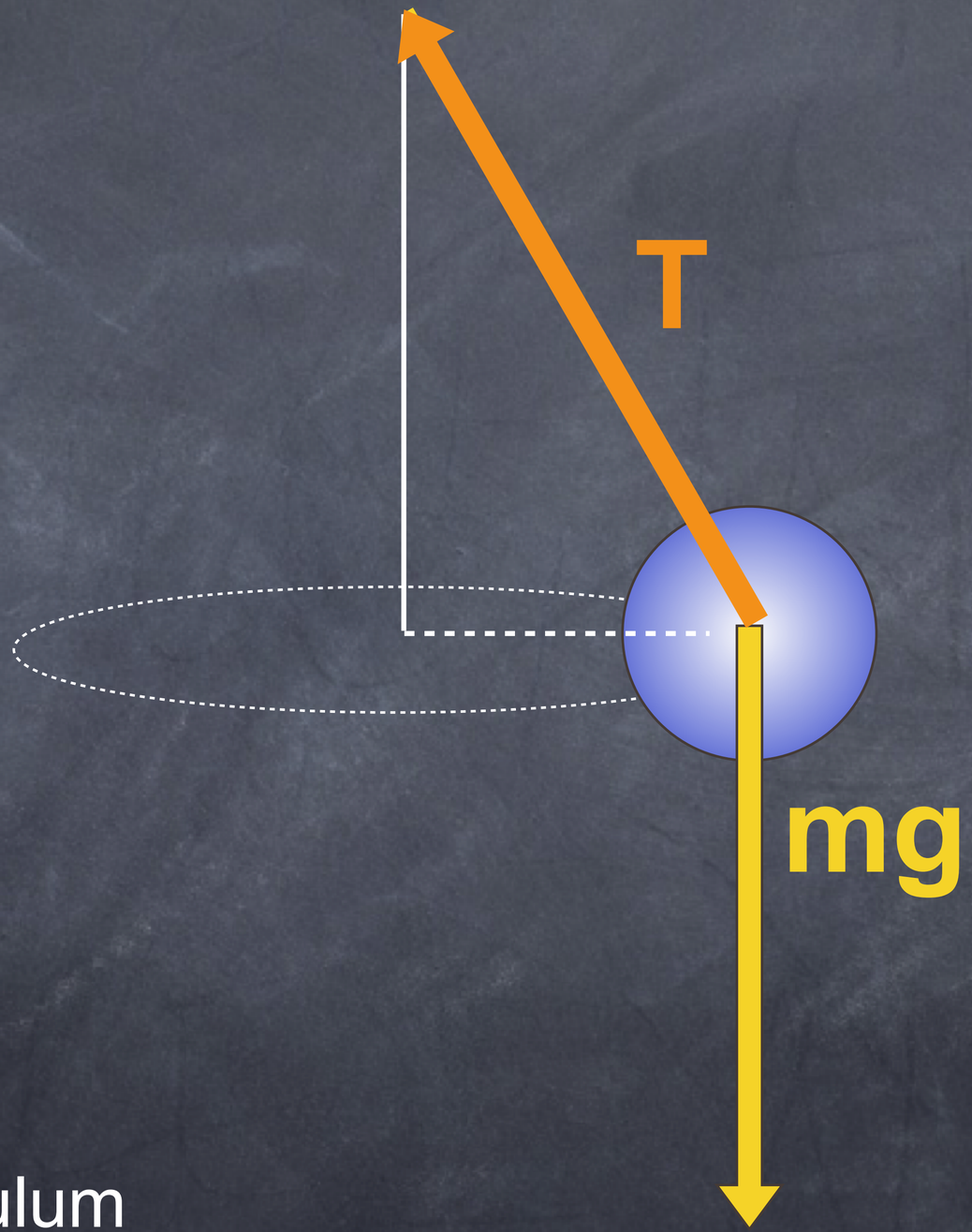

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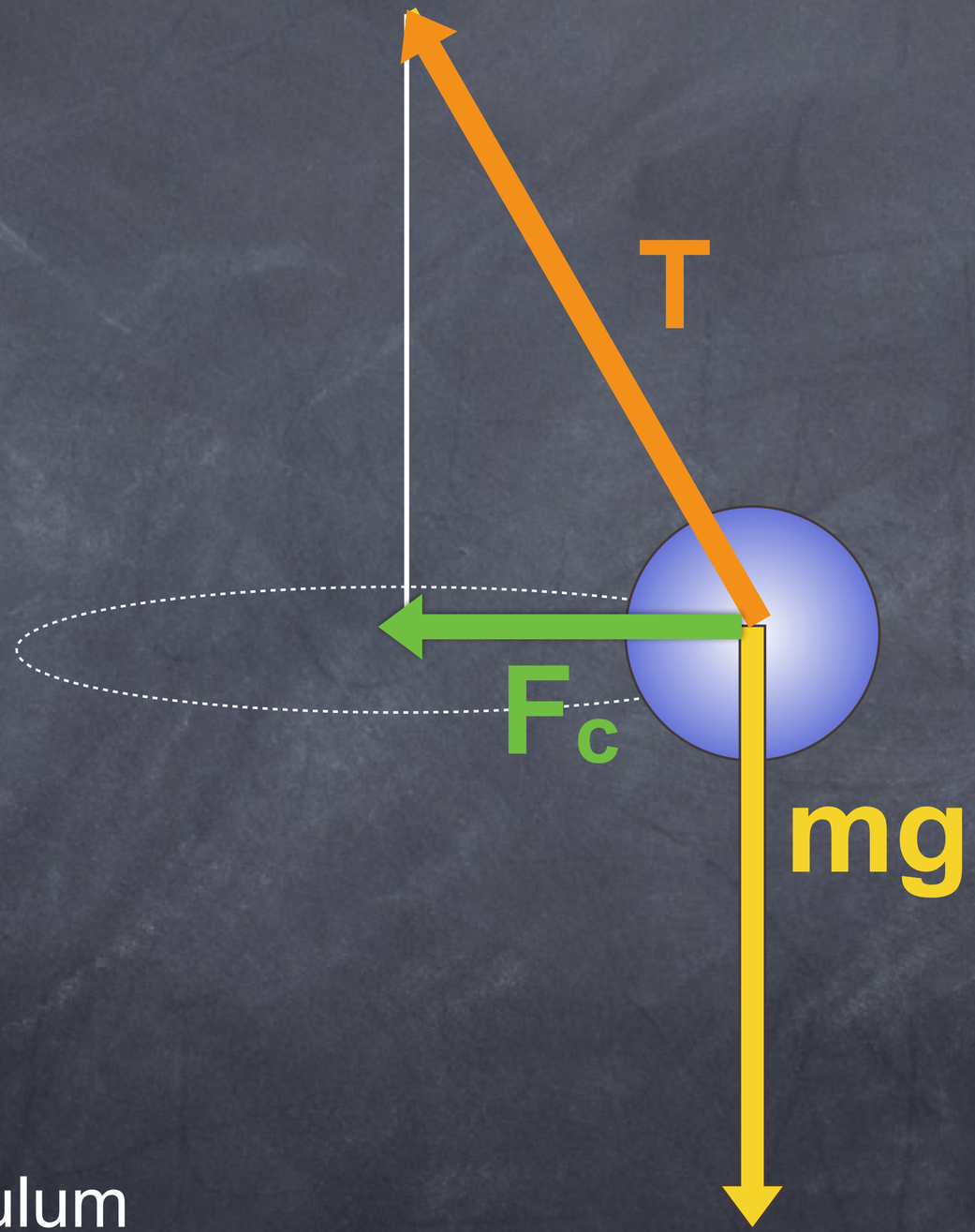

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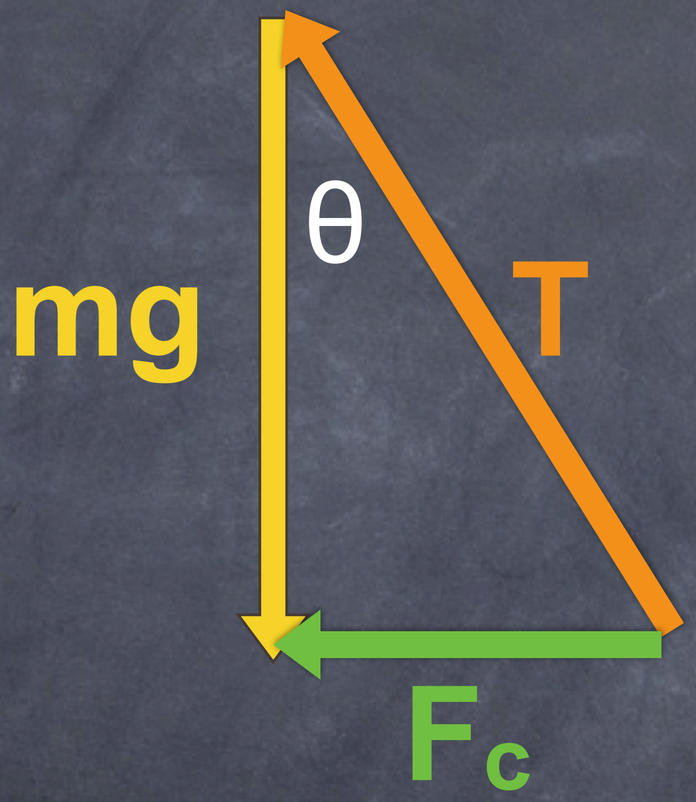
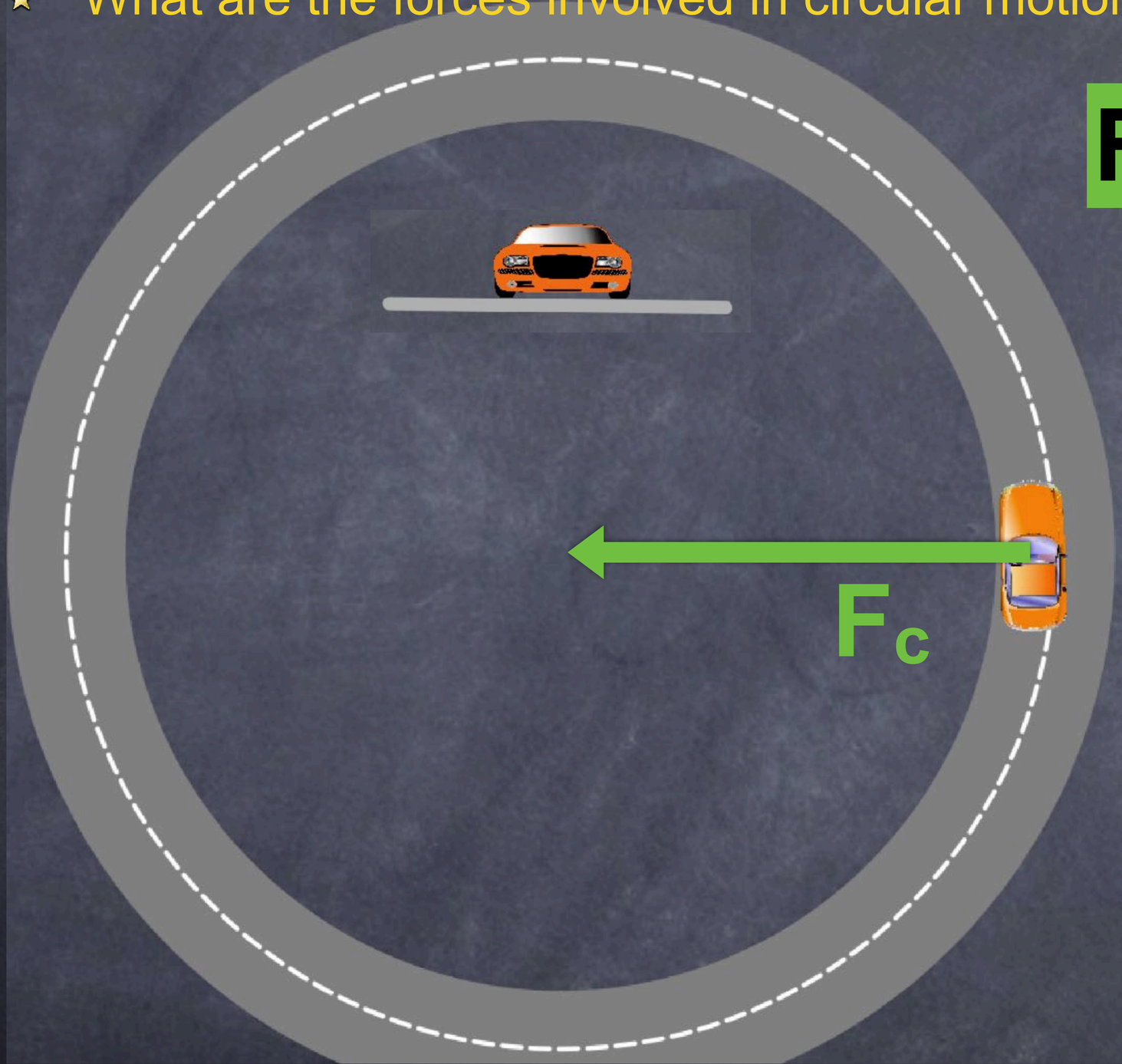


$$\tan\theta = \frac{F_c}{mg}$$

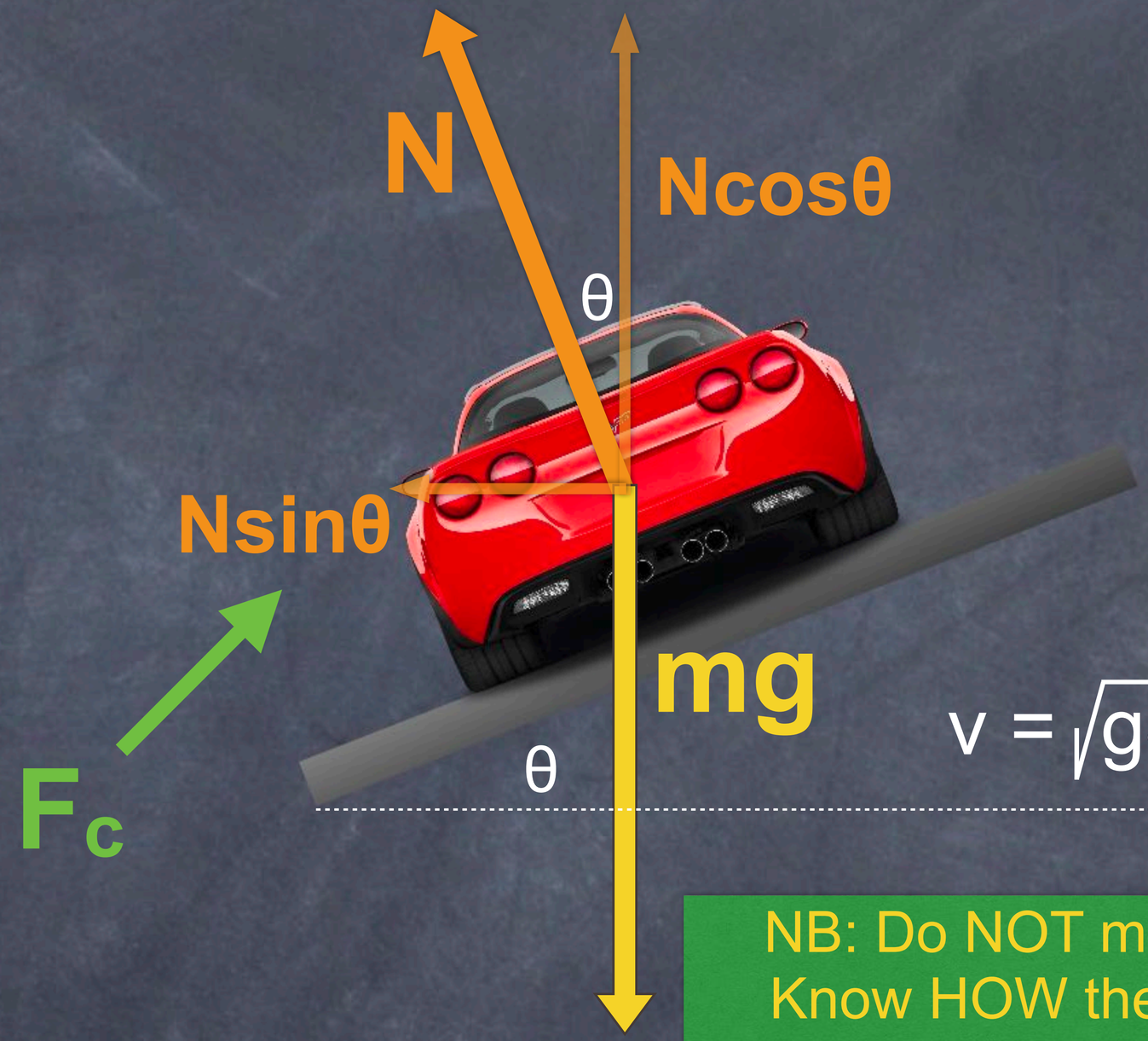
$$v = \sqrt{g \cdot r \cdot \tan\theta}$$

Conical pendulum

- What are the forces involved in circular motion?



$$F_c = \mu N = \mu mg$$



$$v = \sqrt{g \cdot r \cdot \tan\theta}$$

NB: Do NOT memorise the formula
Know HOW the formula is derived.
This is true for many formulas in physics

Banked roads

- Energy

It comes from the work done in the system

$$U_i + K_i + W = U_f + K_f$$

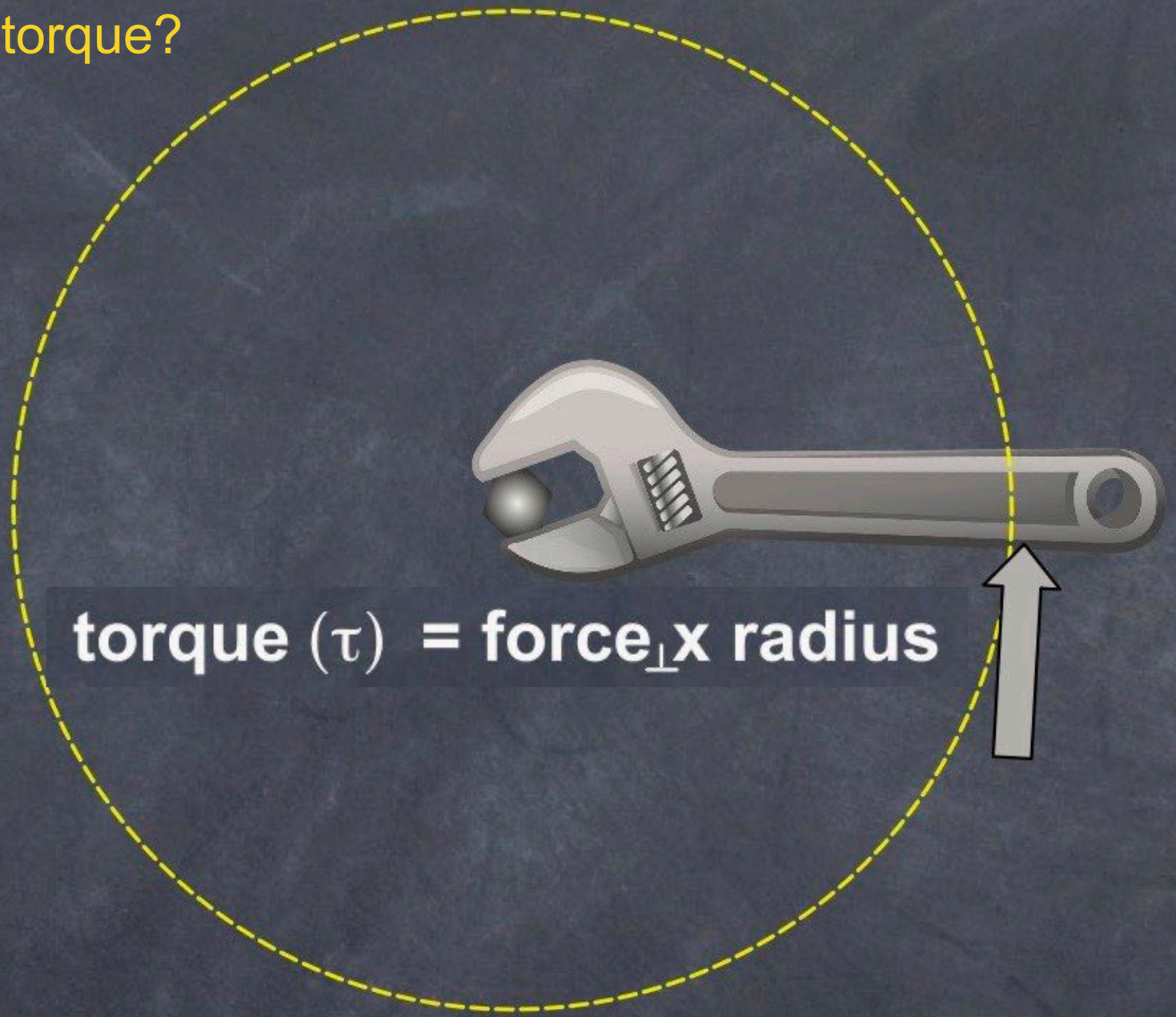
where the work done is positive since $E_i < E_f$

If the carousel is made to slow down, then

$$U_i + K_i + W = U_f + K_f$$

where the work done is negative since $E_i < E_f$

- What is torque?



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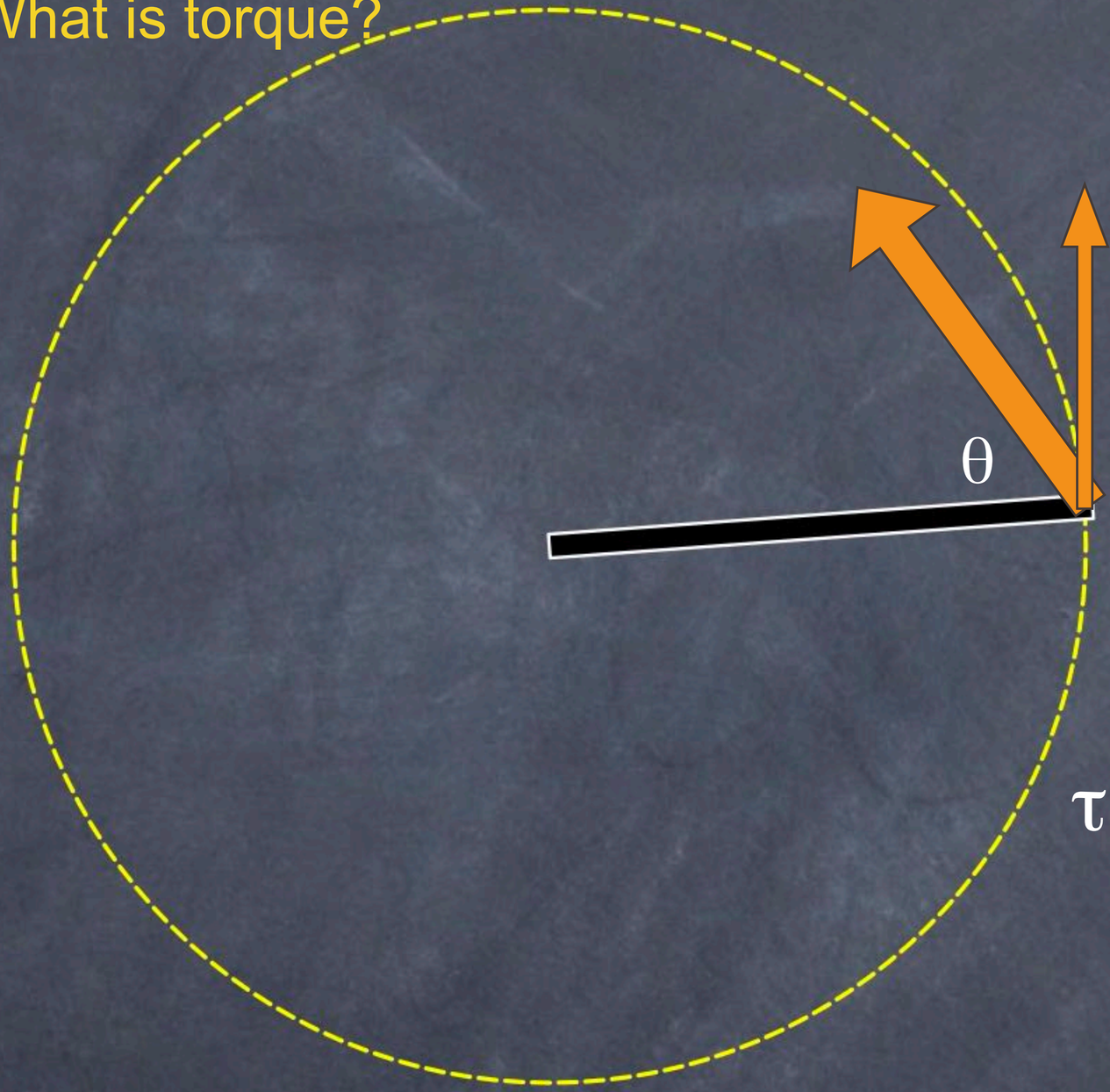
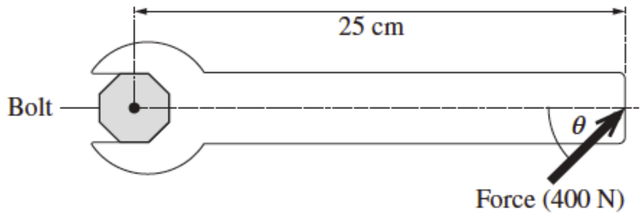


$\tau = F \cdot r \cdot \sin\theta$

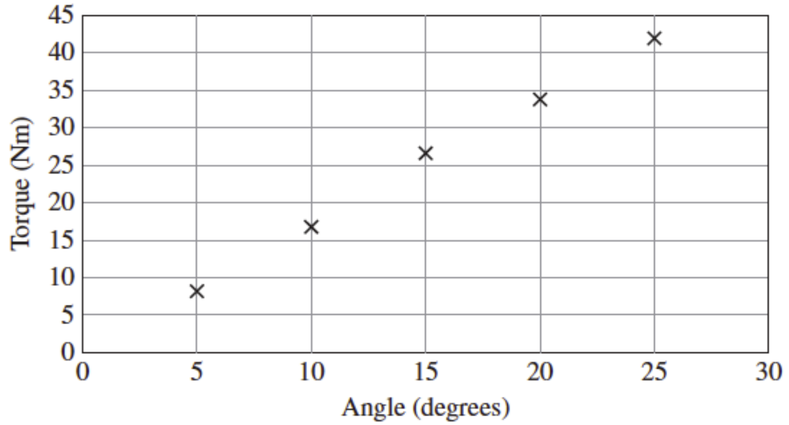
Question 26 (6 marks)

A student carried out an experiment to investigate the relationship between the torque produced by a force and the angle at which the force is applied. A 400 N force was applied to the same position on the handle of a spanner at different angles, as shown.



A high-precision device measured the torque applied to the bolt.

The data from the experiment is graphed below.



The student concluded that the torque (τ) was proportional to the angle (θ) and proposed the model

$$\tau = k\theta$$

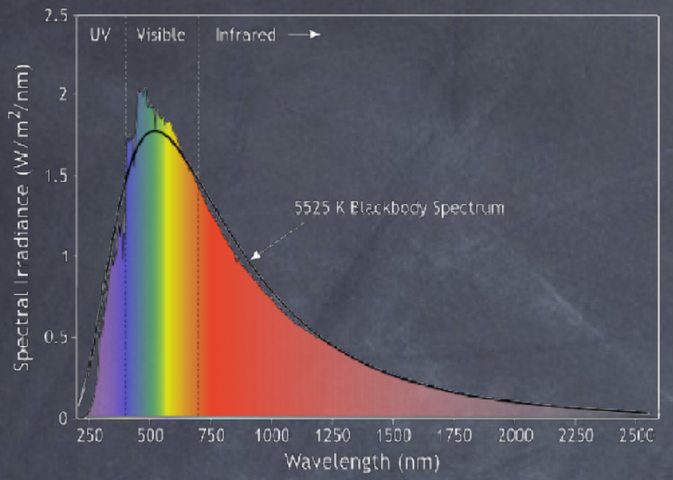
where $k = 1.7$ Nm/degree.

(a) Justify the validity of the student's model using information from the graph. **3**

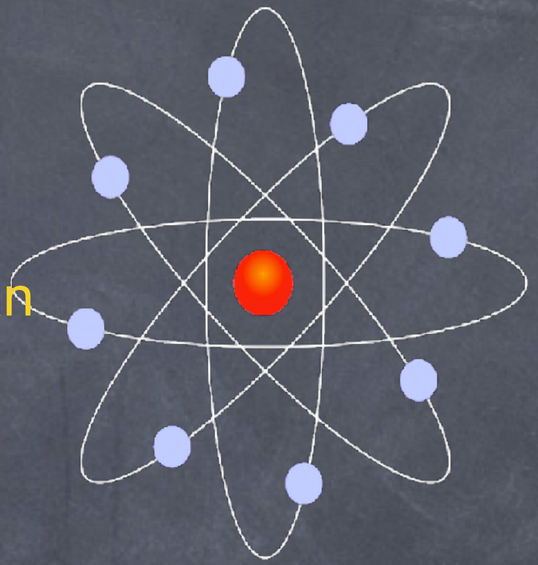
(b) What happens to the accuracy of this model's predictions as the angle increases beyond 25°? Justify your answer with reference to a different model. **3**

Know about
- experimental design
- Models and how we validate them

Models



A representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea.



$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

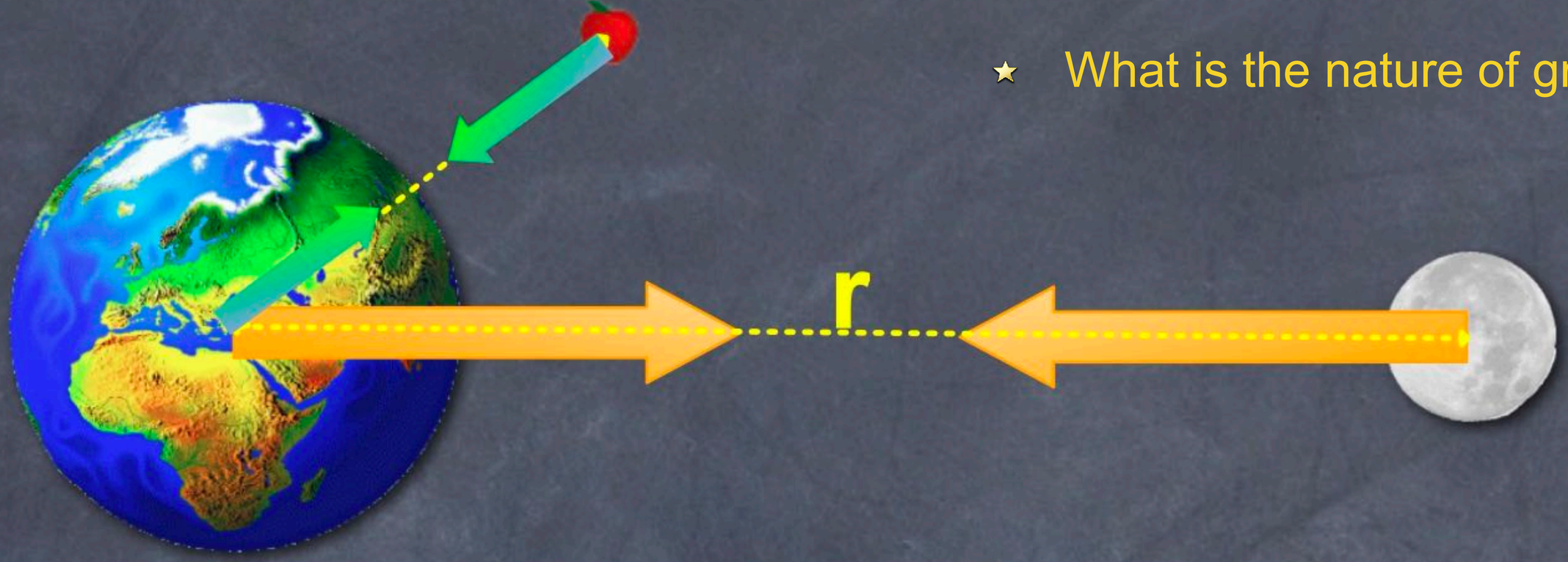
The term ‘model’ refers to a simplified and stylised version of the part or aspect of the universe in which we are interested.

- a model is *a simplification*
- a model can be *descriptive* or *explanatory*
- a model can be used to make predictions
- a model’s predictive capacity has *limitations*

How does the force of gravity determine the motion of planets and satellites?

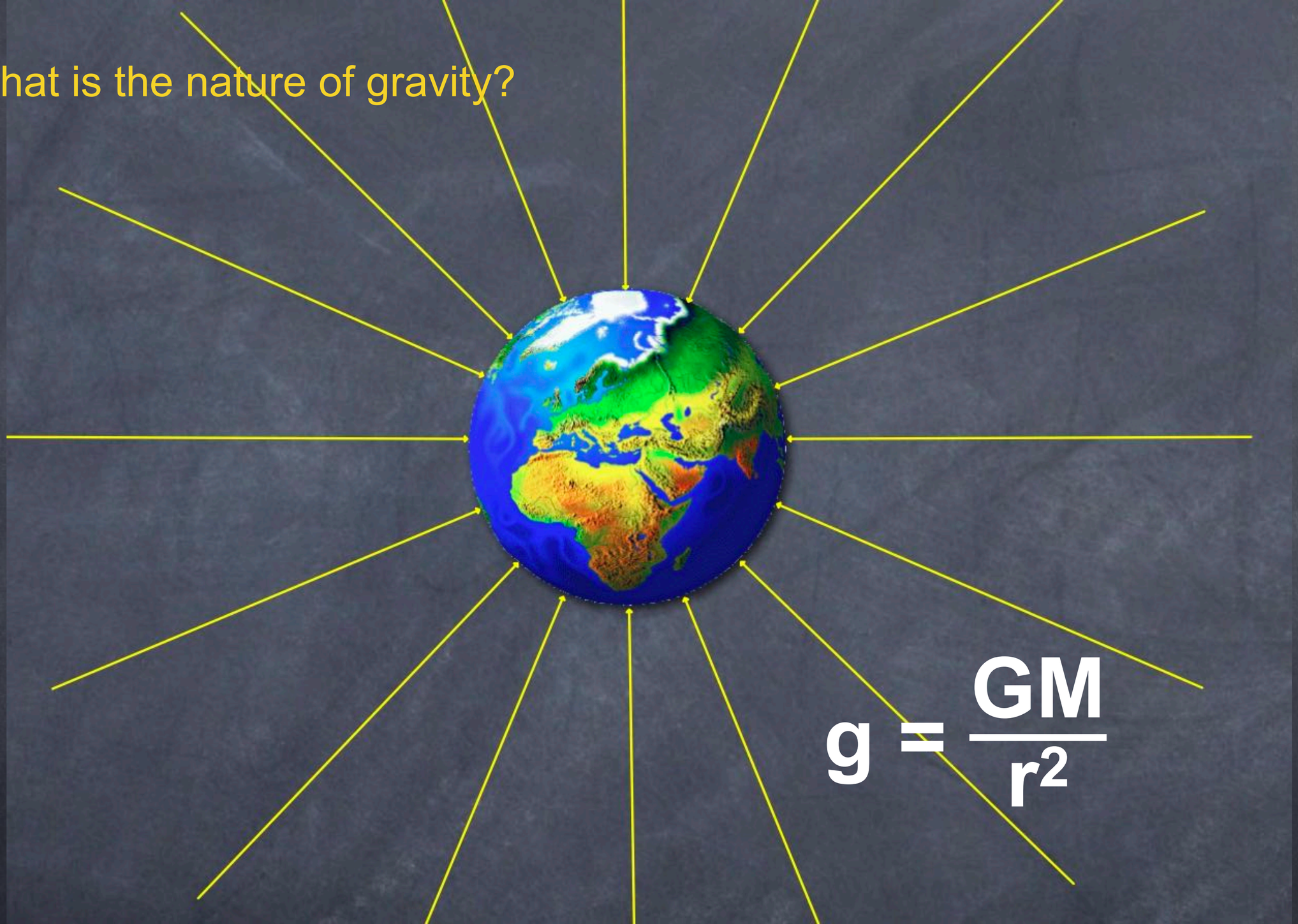
- What is the nature of gravity?
- How does gravity affect the motion of planets and satellites?
- Examine satellites in orbit mathematically
- What are Kepler's Laws?
- Energy and gravity

- What is the nature of gravity?



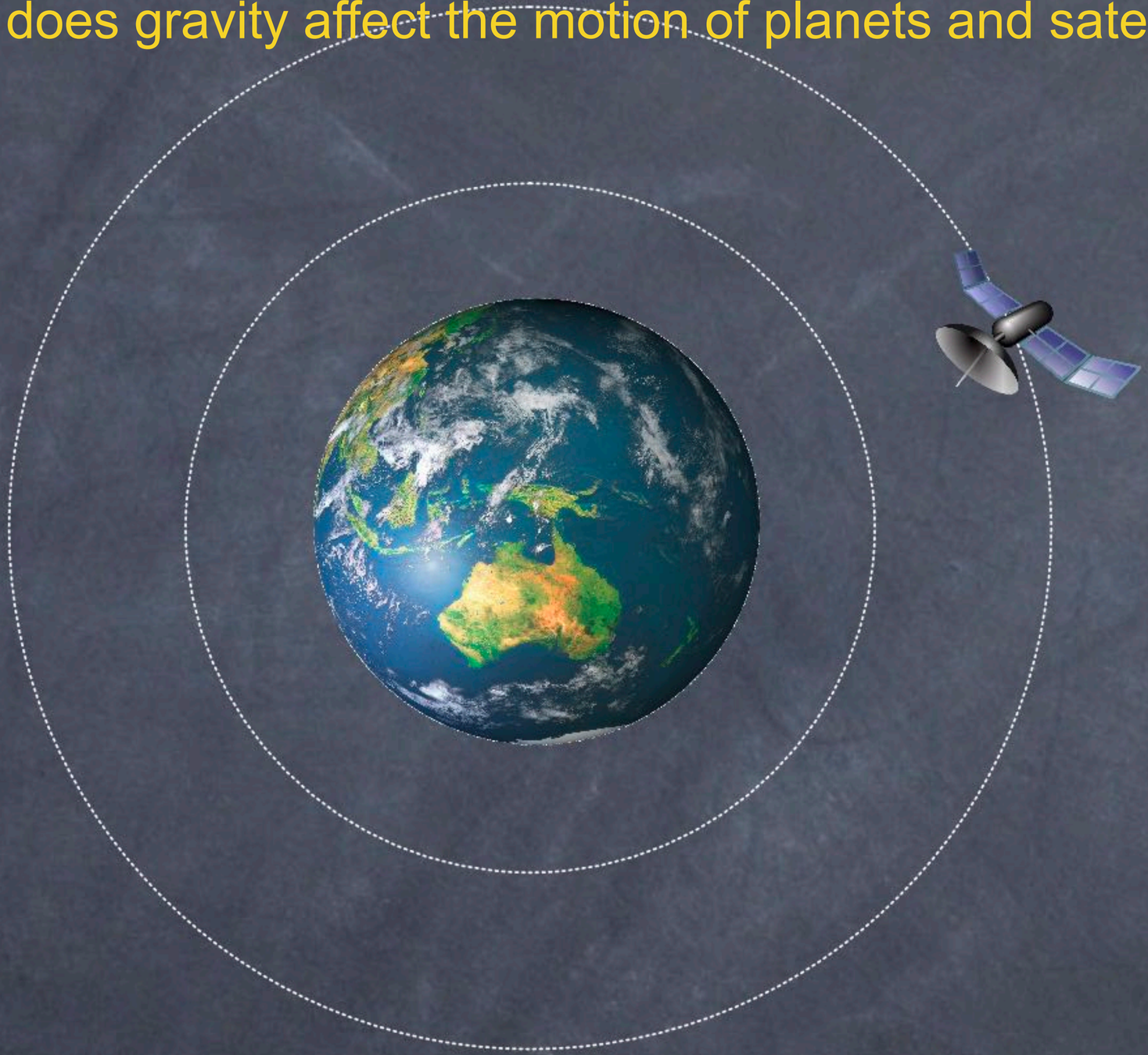
$$F = G \frac{m_1 m_2}{r^2}$$

- What is the nature of gravity?



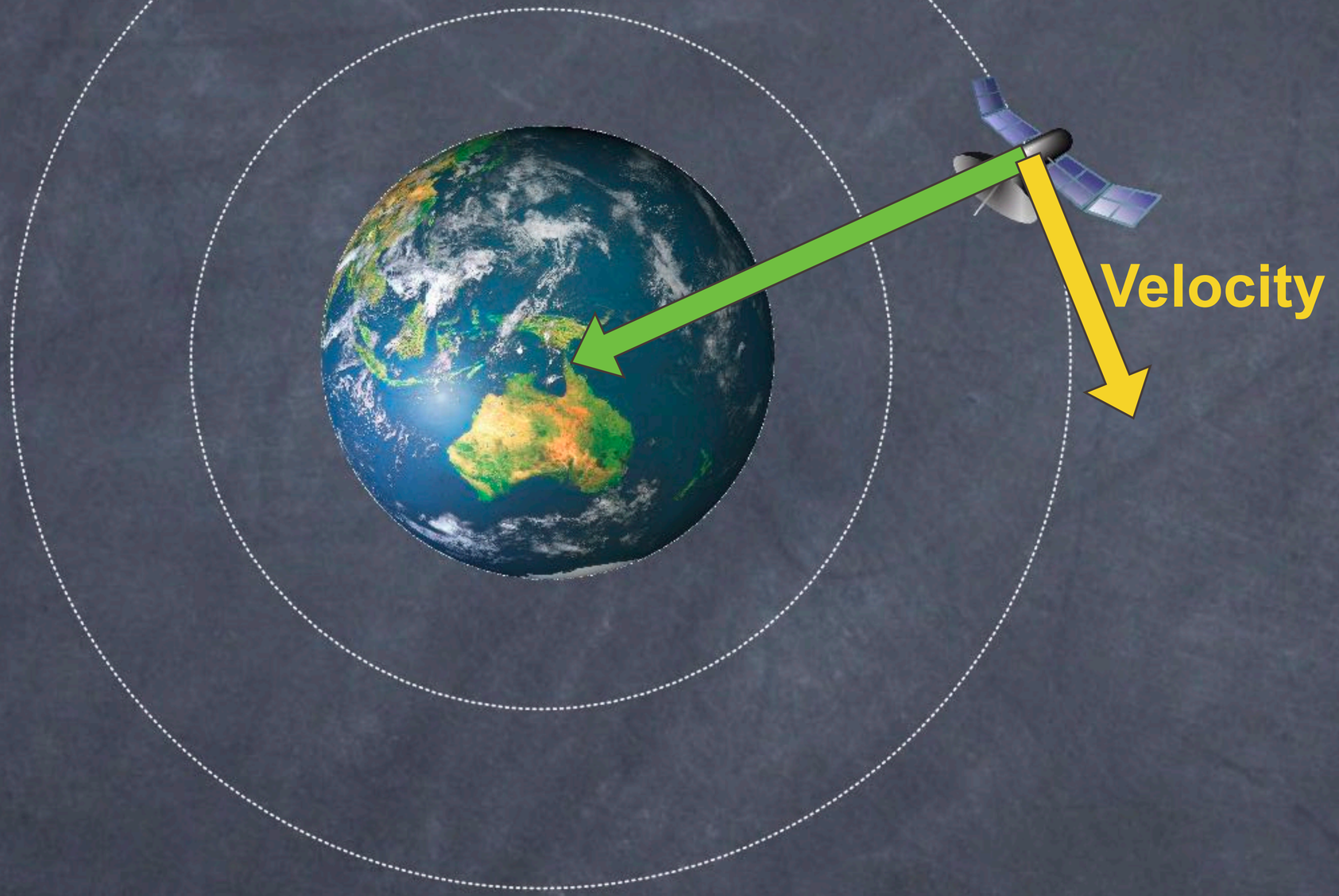
$$g = \frac{GM}{r^2}$$

- How does gravity affect the motion of planets and satellites?

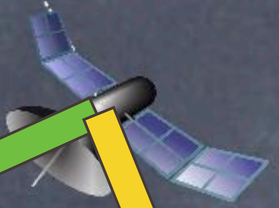


- How does gravity affect the motion of planets and satellites?

Gravitational force = Centripetal force



Gravitational force = Centripetal force



Velocity

$$v = \sqrt{\frac{G \cdot M}{r}}$$

A satellite in circular orbit at a distance r from the centre of Earth has an orbital velocity v.

If the distance was increased to $2r$, what would be the satellite's orbital velocity?

A. $\frac{v}{2}$

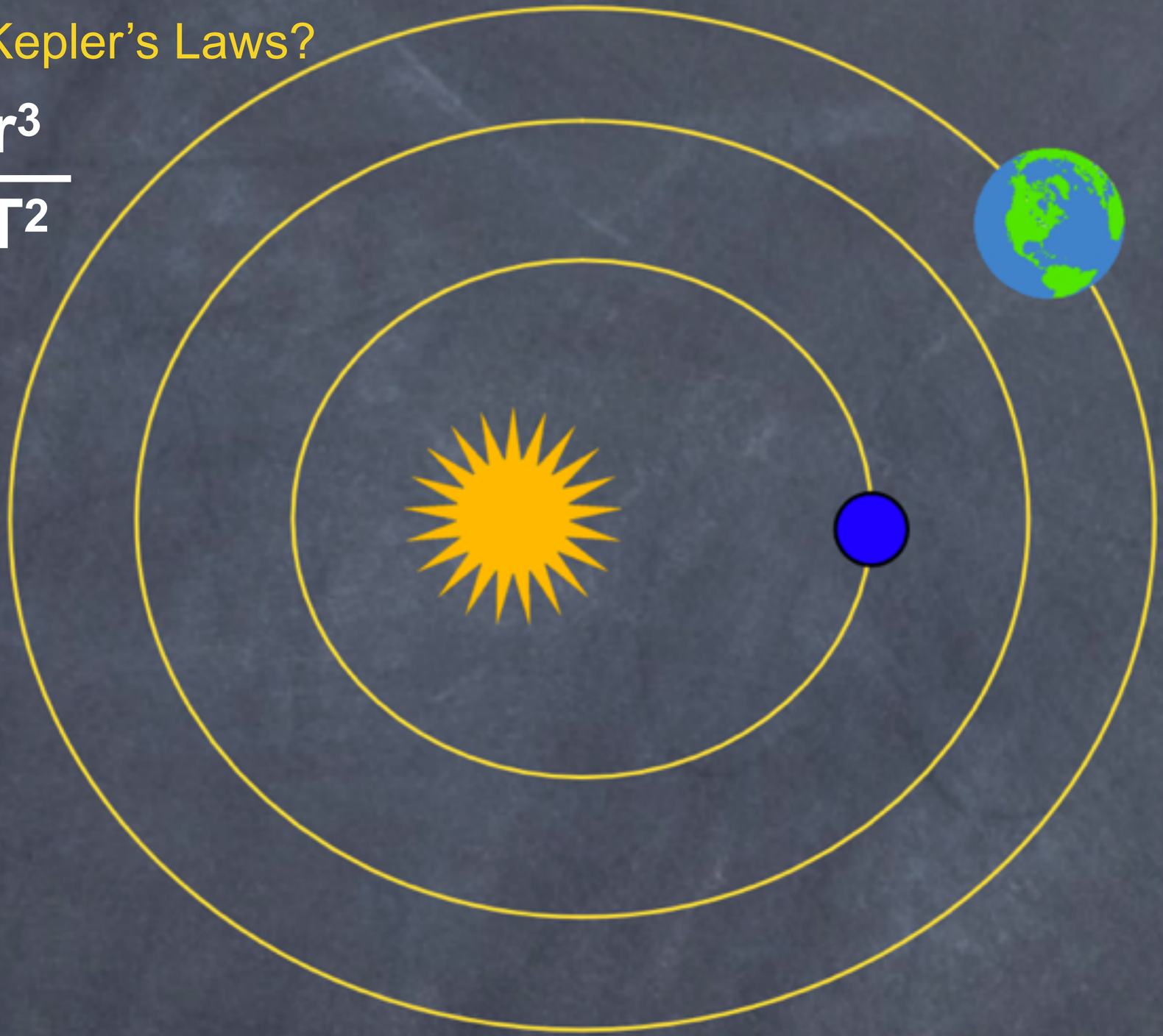
B. $0.7v$

C. $1.4v$

D. $2v$

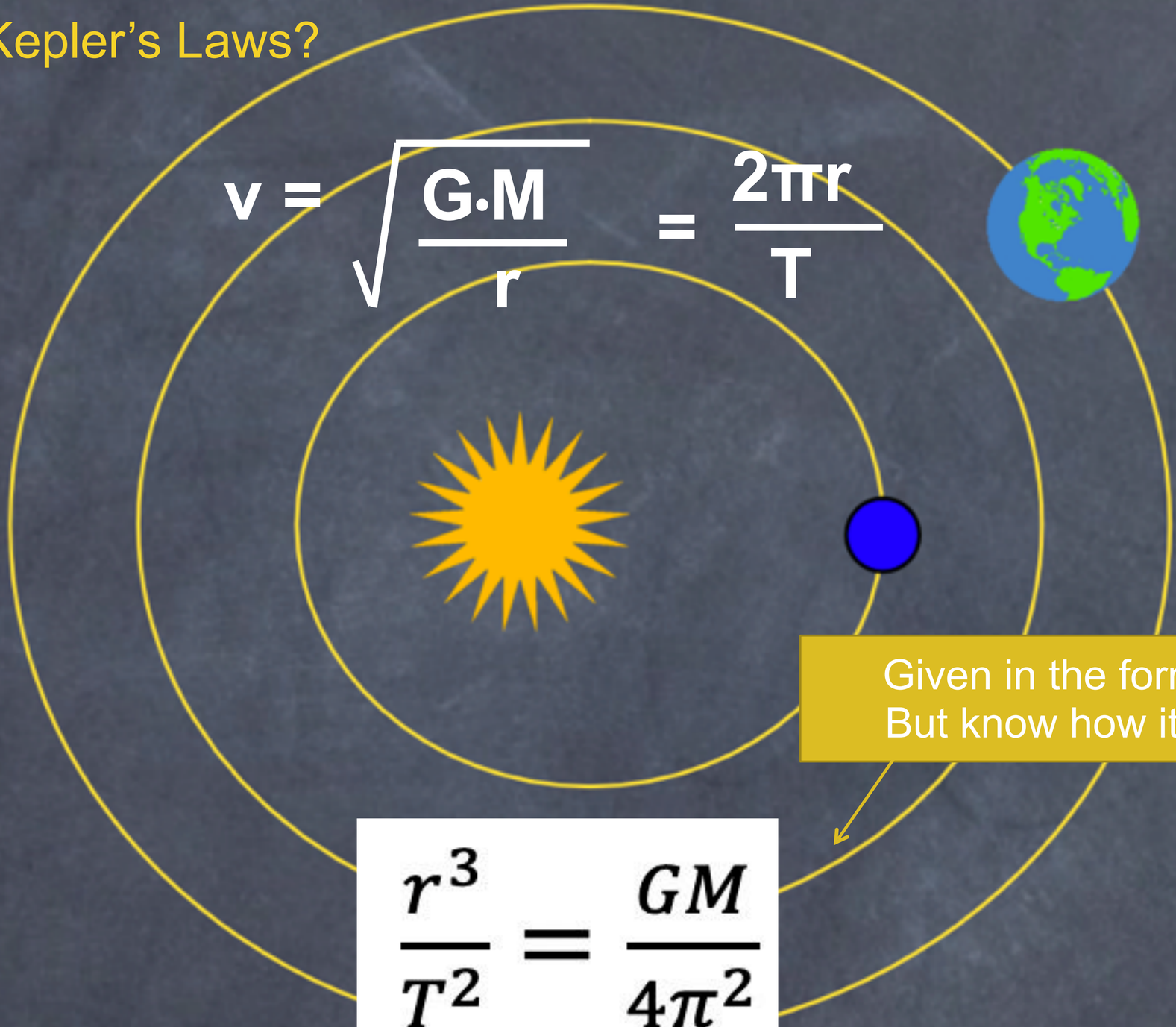
- What are Kepler's Laws?

$$\frac{r^3}{T^2}$$



What are Kepler's Laws?

$$v = \sqrt{\frac{G \cdot M}{r}} = \frac{2\pi r}{T}$$



Given in the formula sheet
But know how it is derived

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

A dwarf planet orbits the sun with a period of 40 000 years.

The average distance from the sun to Earth is one astronomical unit.

What is the average distance between this dwarf planet and the sun in astronomical units?

A. 34

B. 200

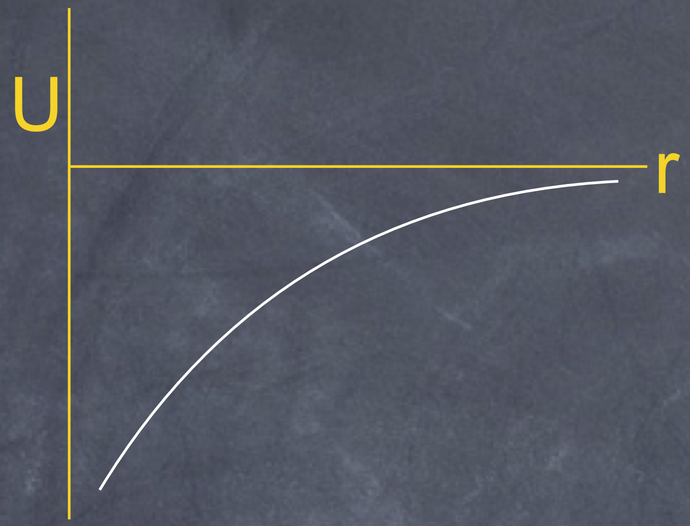
C. 1170

D. 8×10^6

$$\frac{r_1^3}{T_1^2} = \frac{r_2^3}{T_2^2}$$

$$\frac{r_1^3}{40000^2} = \frac{1^3}{1^2}$$

Energy and gravity



U = 0

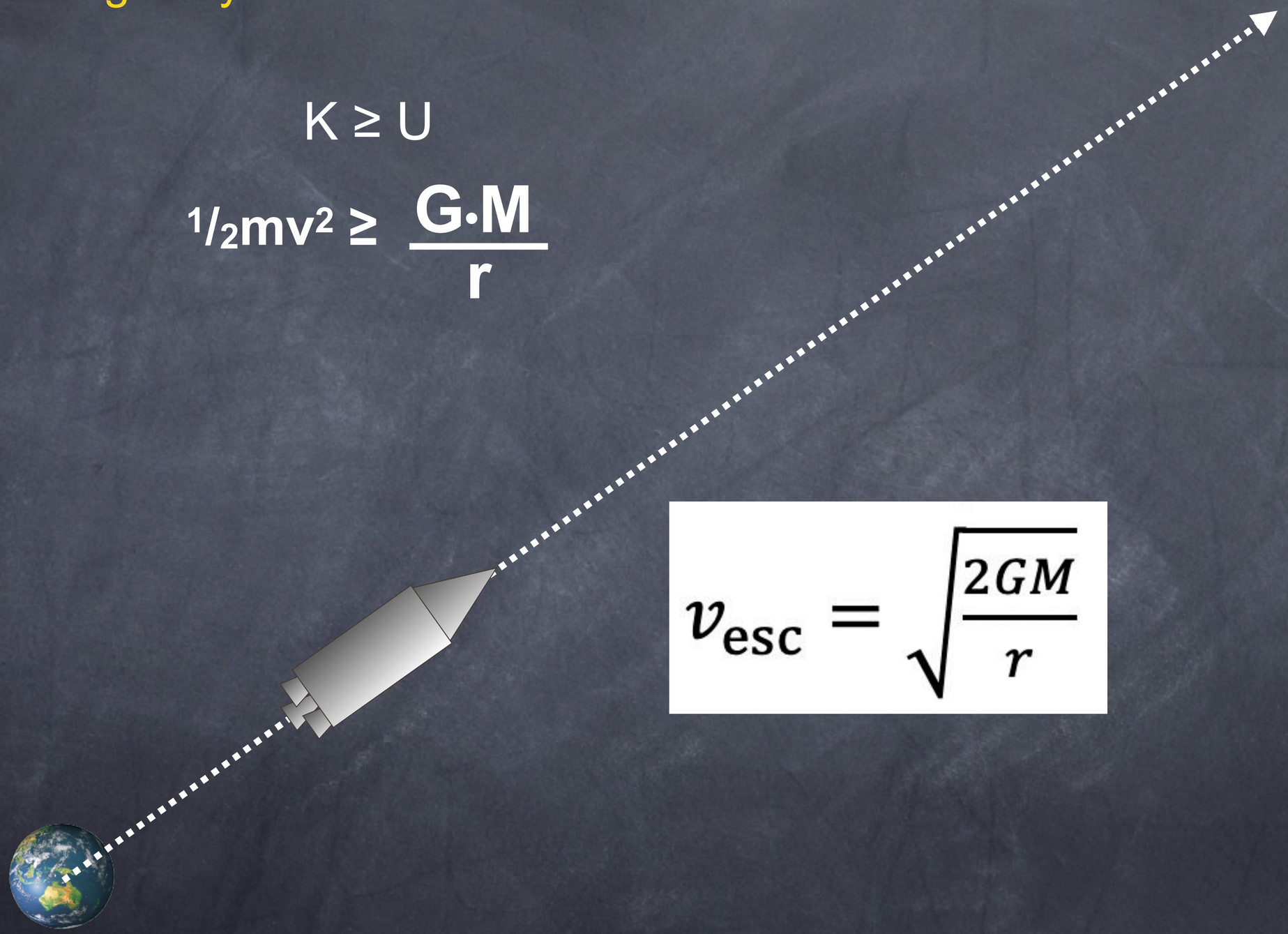
U increasing

$$U = -\frac{GMm}{r}$$

Energy and gravity

$$K \geq U$$

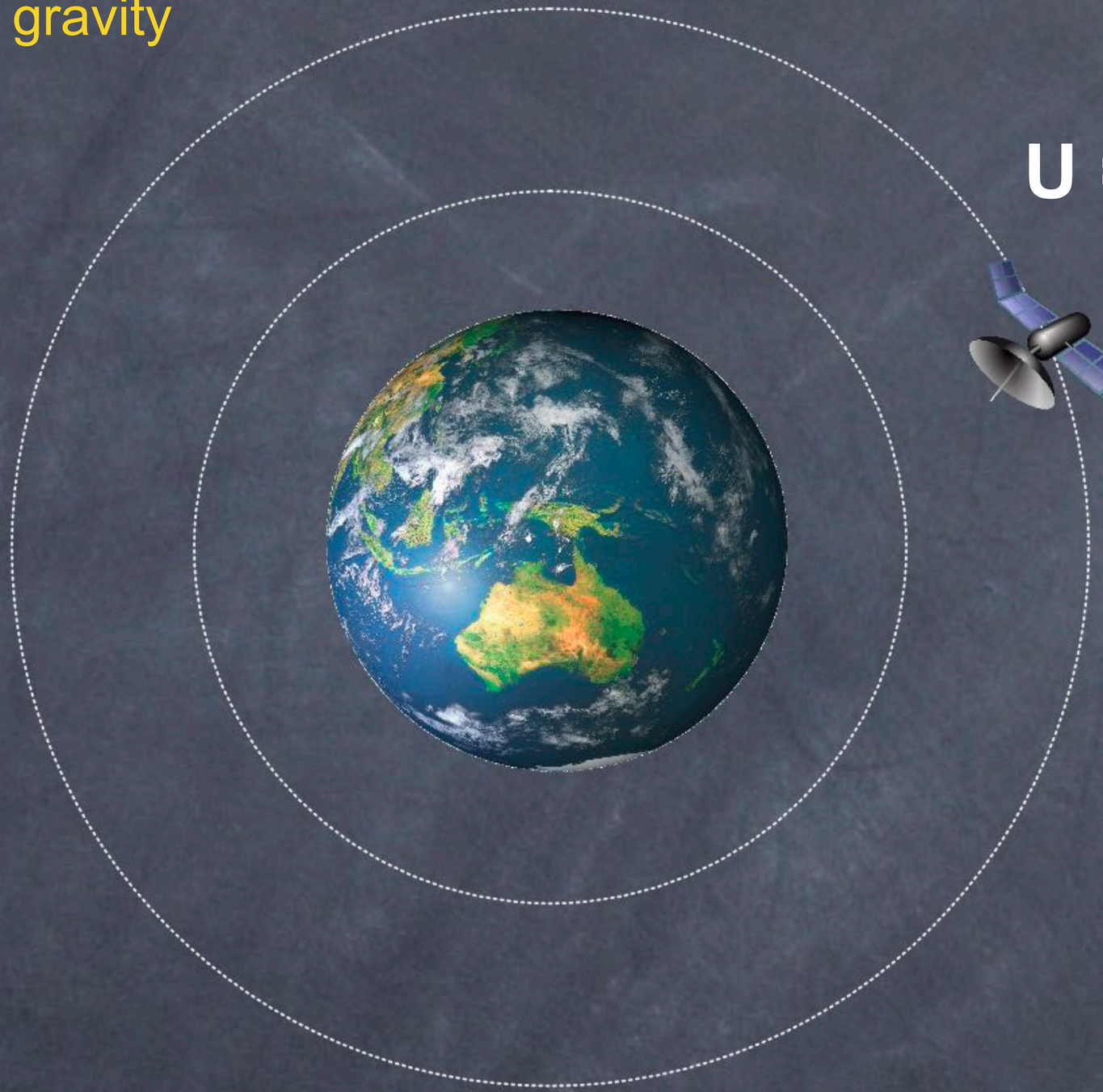
$$\tfrac{1}{2}mv^2 \geq \frac{G \cdot M}{r}$$



$$v_{esc} = \sqrt{\frac{2GM}{r}}$$

Energy and gravity

$$U = -\frac{G \cdot M}{r}$$

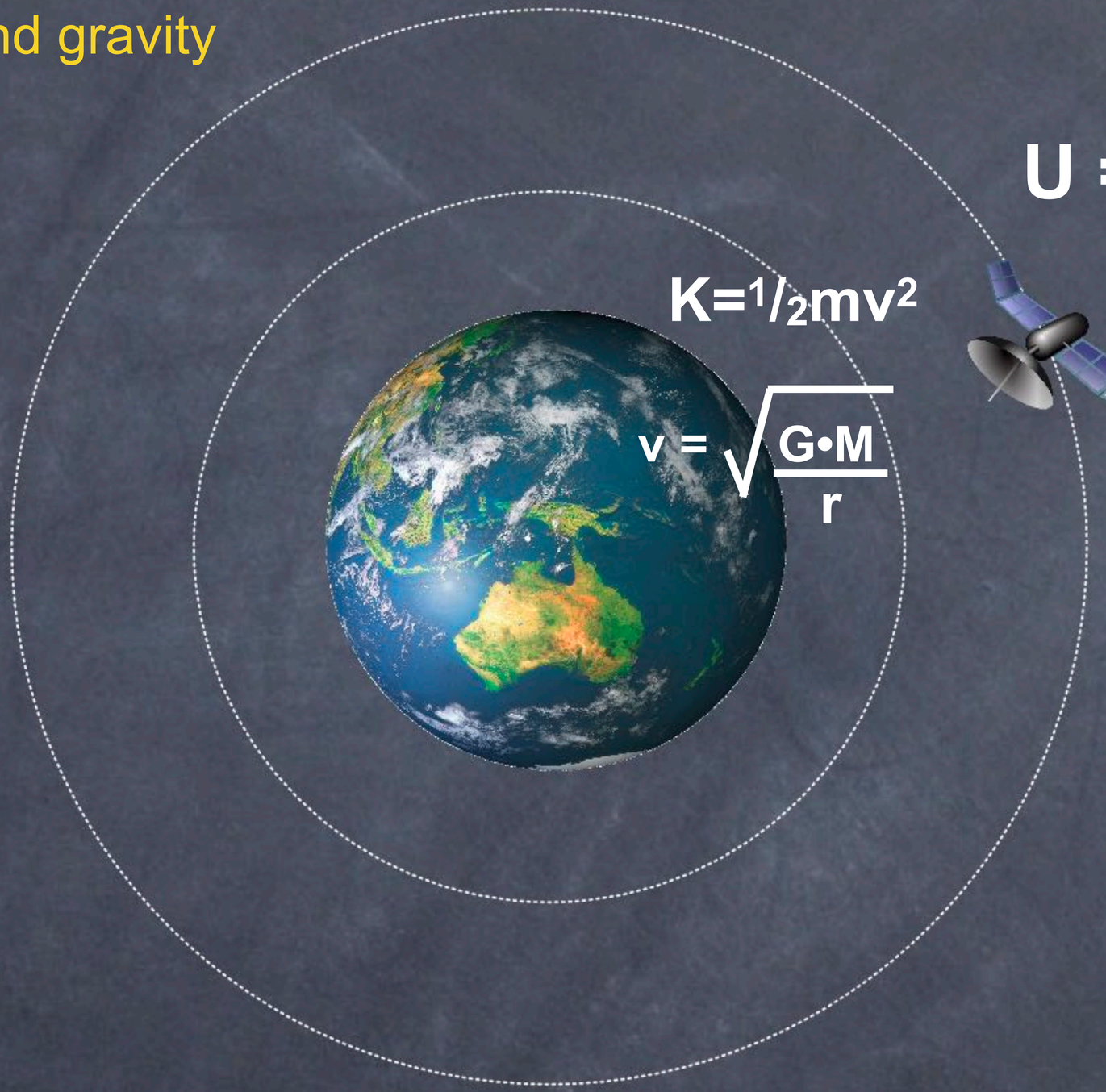


Energy and gravity

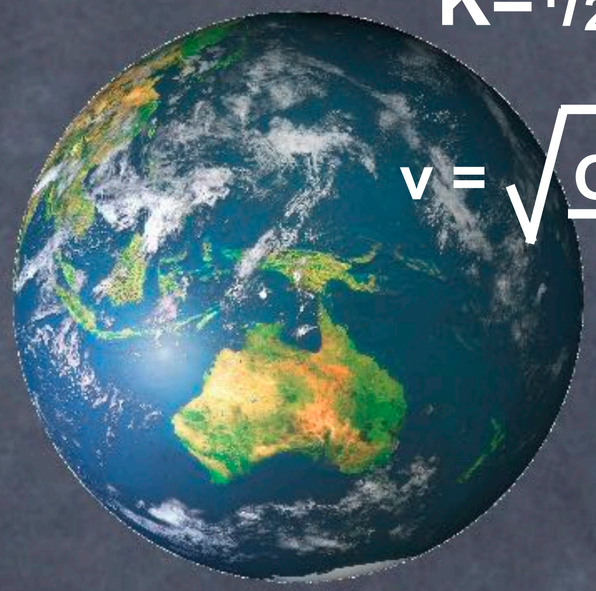
$$U = -\frac{G \cdot M}{r}$$

$$K = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{G \cdot M}{r}}$$



Energy and gravity



$$K = \frac{1}{2}mv^2$$

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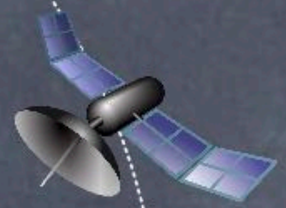
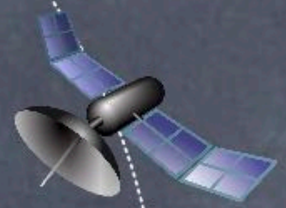


$$U = -\frac{G \cdot M}{r}$$

$$K = \frac{G \cdot M}{2r}$$

Energy and gravity

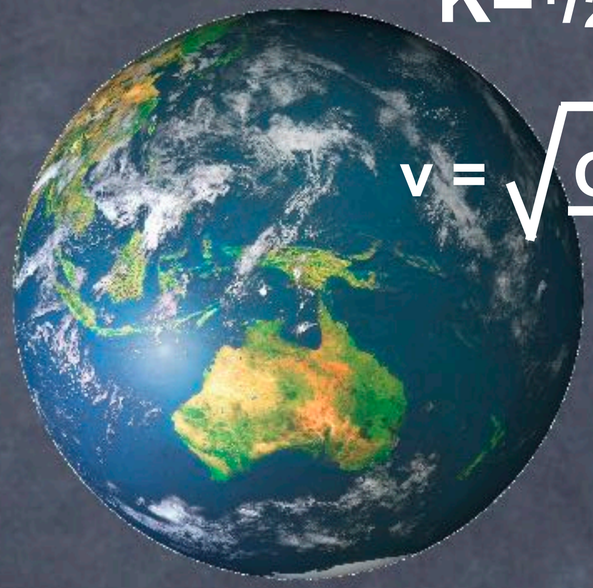
$$U = -\frac{G \cdot M}{r}$$



$$K = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{G \cdot M}{r}}$$

$$K = \frac{G \cdot M}{2r}$$

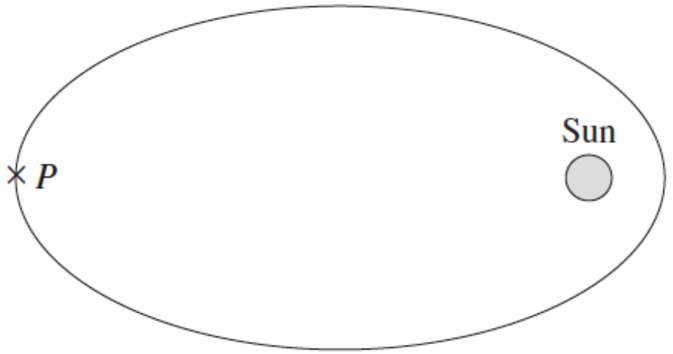


$$U + K = -\frac{GMm}{2r}$$

Question 31

6 marks

(a) The orbit of a comet is shown. **3**



Account for the changes in velocity of the comet as it completes one orbit from position *P*.

Sample answer:

As the comet moves toward the sun, its gravitational potential energy (GPE) is converted into kinetic energy (KE) consistent with the law of conservation of energy. The increase in KE results in an increase in velocity as it approaches the sun. As it returns to point P, it loses velocity as its KE is converted into GPE.

Criteria	**Marks**
• Accounts for the changes in velocity of the comet	3
• Provides a reason for a change in velocity of the comet	2
• Provides some relevant information	1

Take home

- ACCOUNT – to provide reason why
- Notice plural
- Dont forget the big picture - energy

Module 6

Electromagnetism

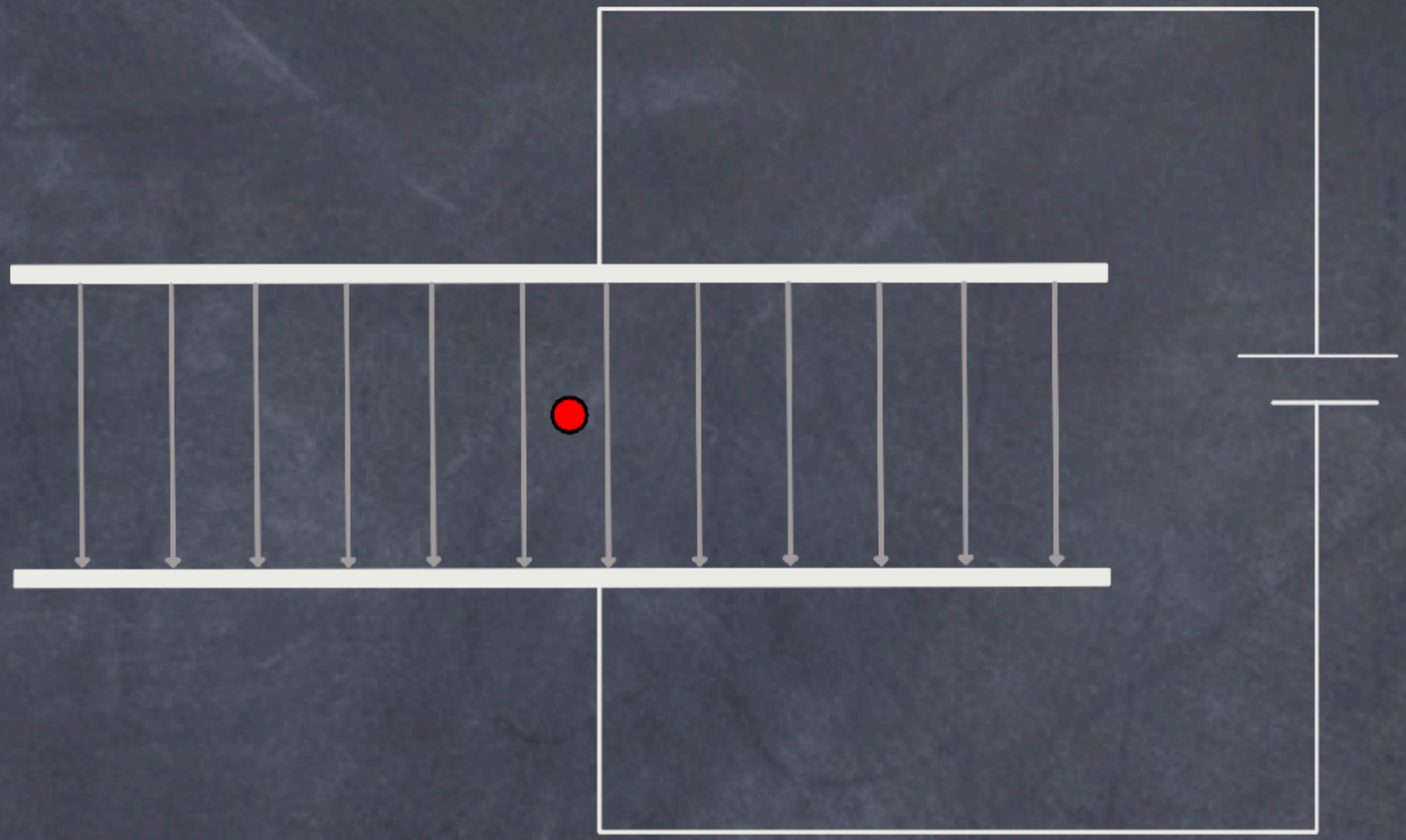
4 inquiry questions

- What happens to stationary and moving charged particles when they interact with an electric or magnetic field?
- Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?
- How are fields related?
- How has knowledge about the Motor Effect been applied to technological advances?

What happens to stationary and moving charged particles when they interact with an electric or magnetic field?

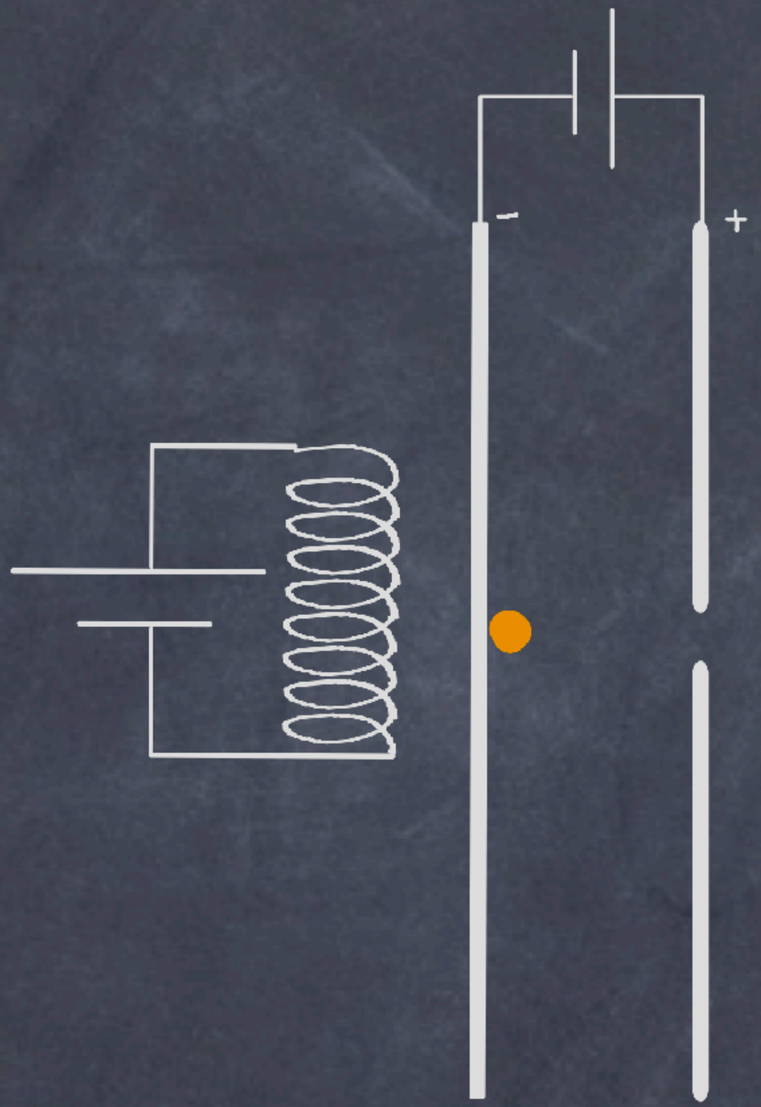
- Charges in electric fields
- Charges in magnetic fields

★What happens to stationary and moving charged particles when they interact with an electric or magnetic field?



$$E = \frac{F}{q} = \frac{V}{d} \qquad \therefore F = \frac{qV}{d}$$

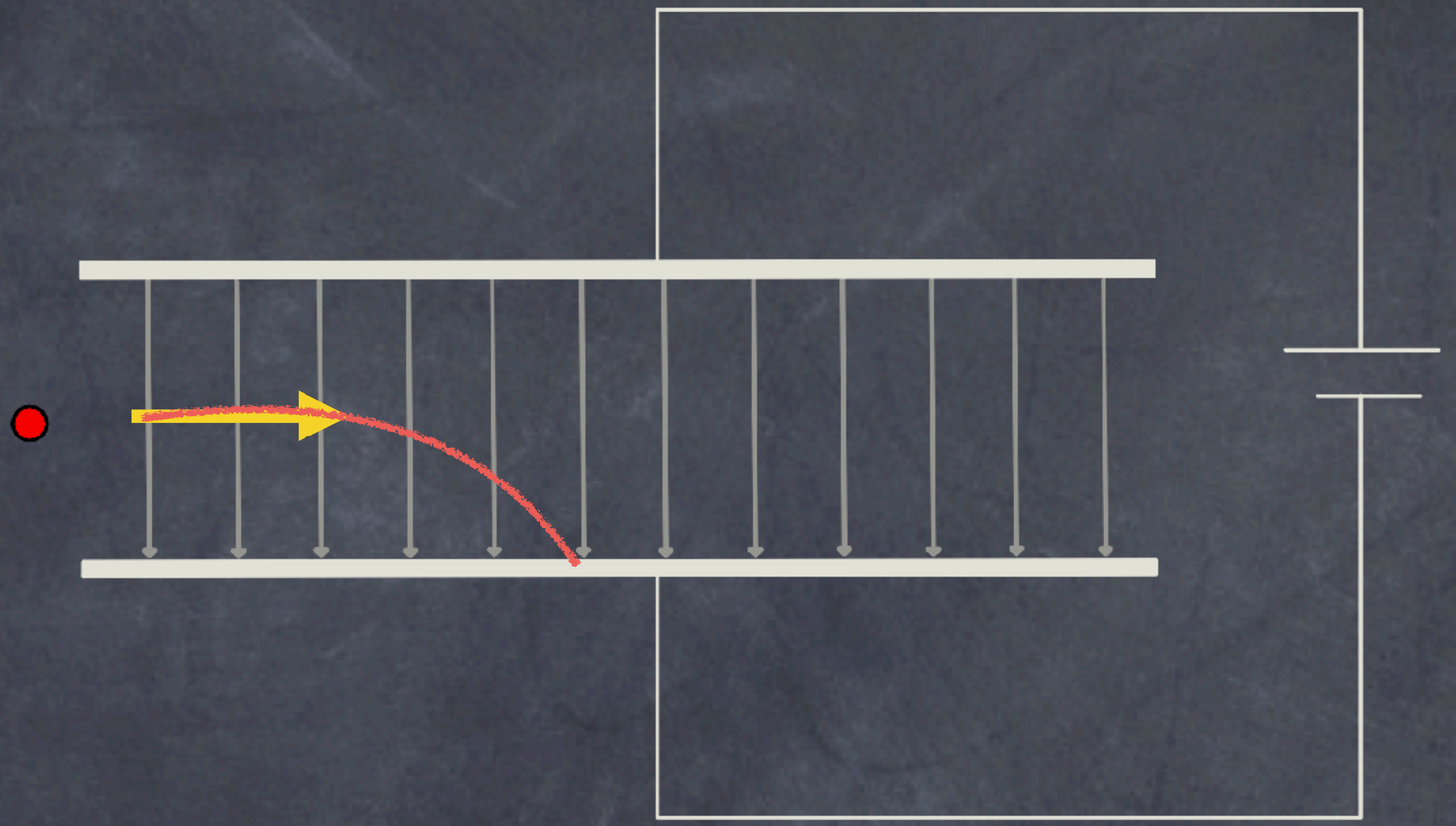
★What happens to stationary and moving charged particles when they interact with an electric or magnetic field?

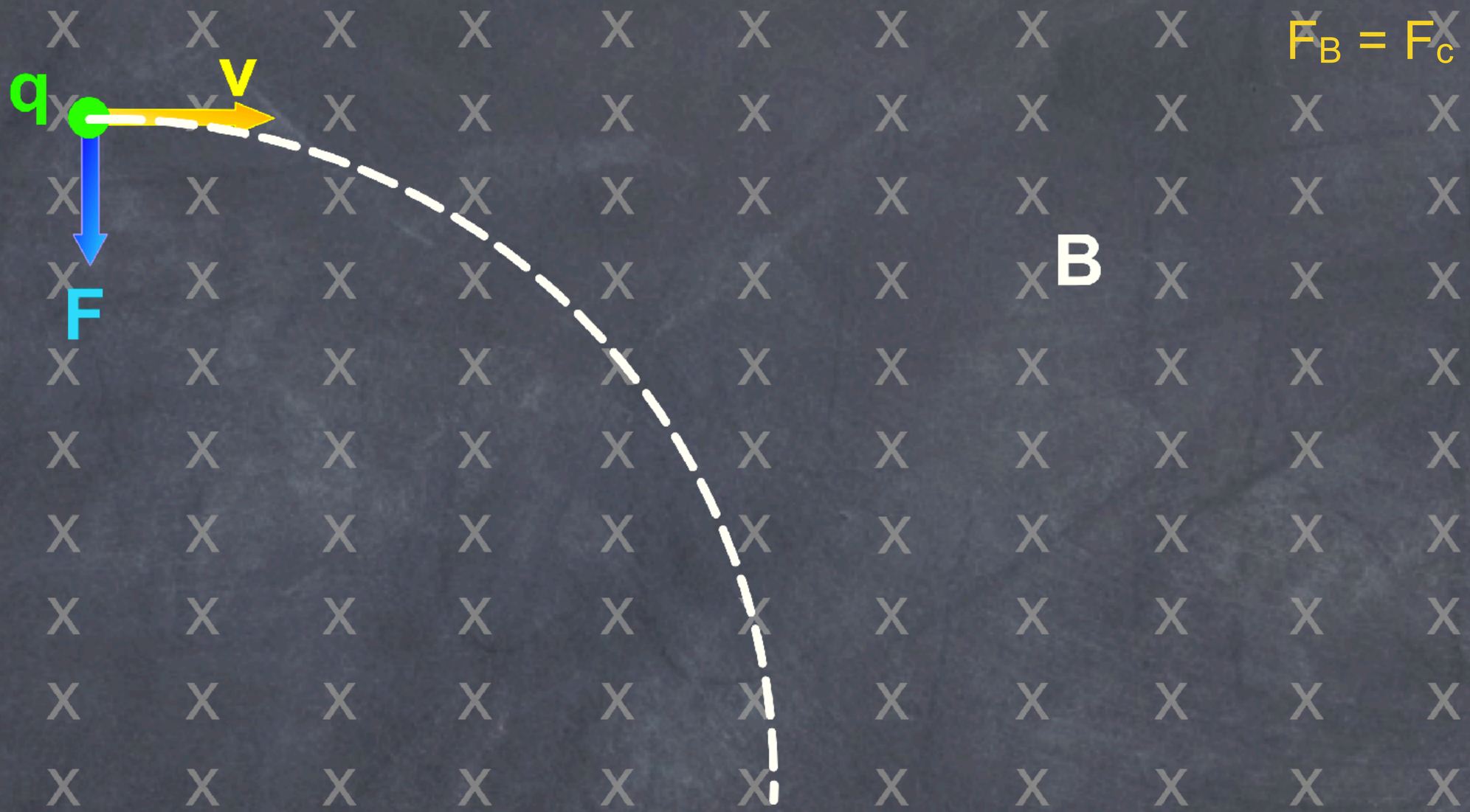


$$W = Fd = Eqd = Vq$$

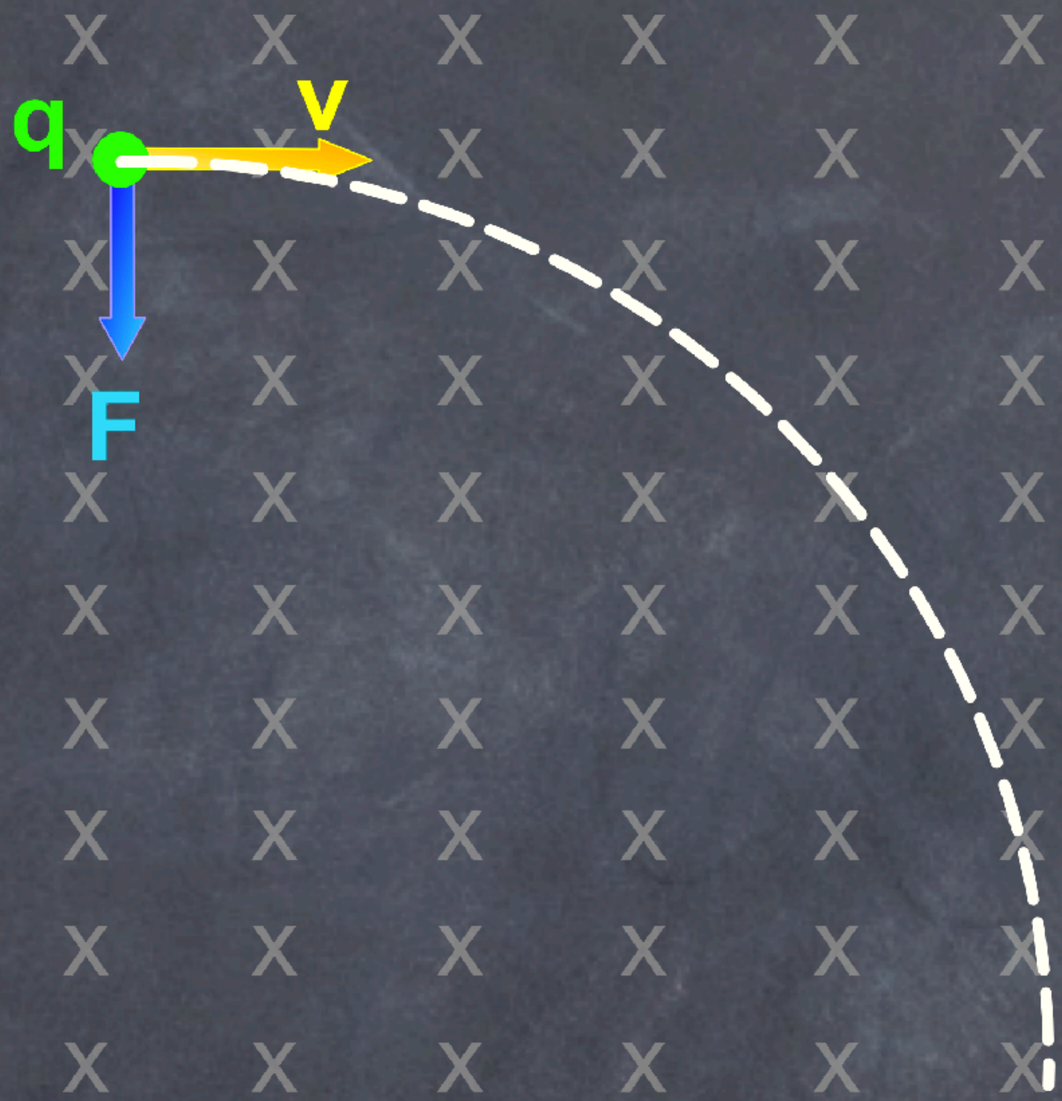
$$W = Vq = \Delta K = {}^{1}/_{2}\, mv^2$$

★What happens to stationary and moving charged particles when they interact with an electric or magnetic field?





$F_B = F_c$



$F_B = F_C$

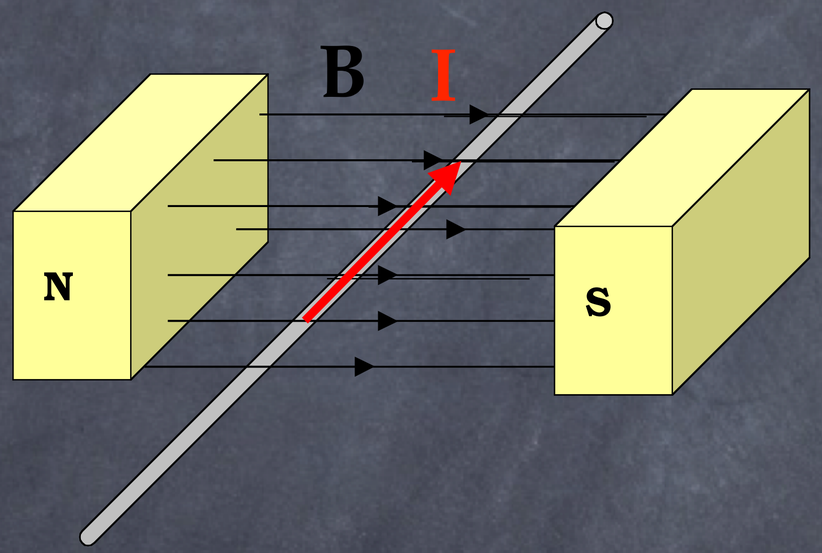
$$Bqv = \frac{mv^2}{r}$$

$$Bq = \frac{mv}{r}$$

$$\frac{q}{m} = \frac{v}{Br}$$

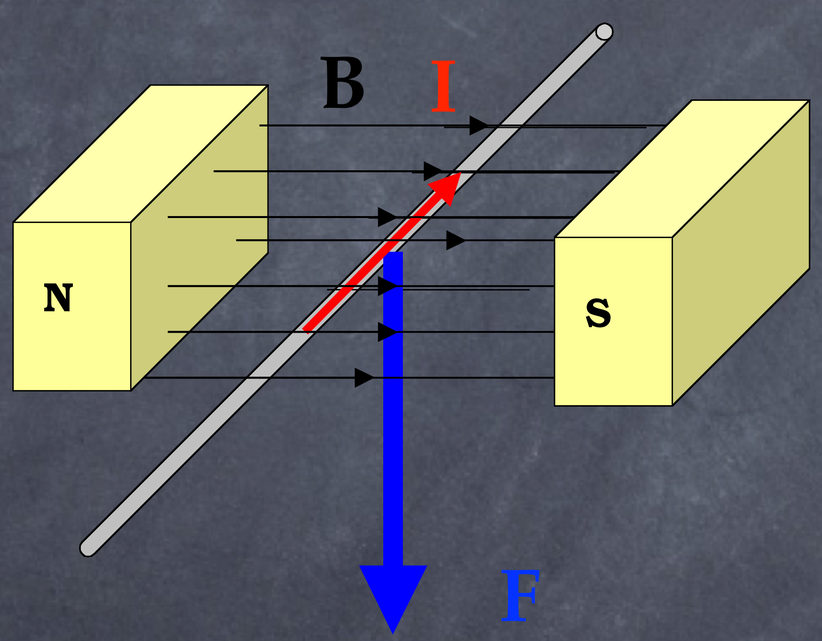
★Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Motor Effect



★Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Motor Effect



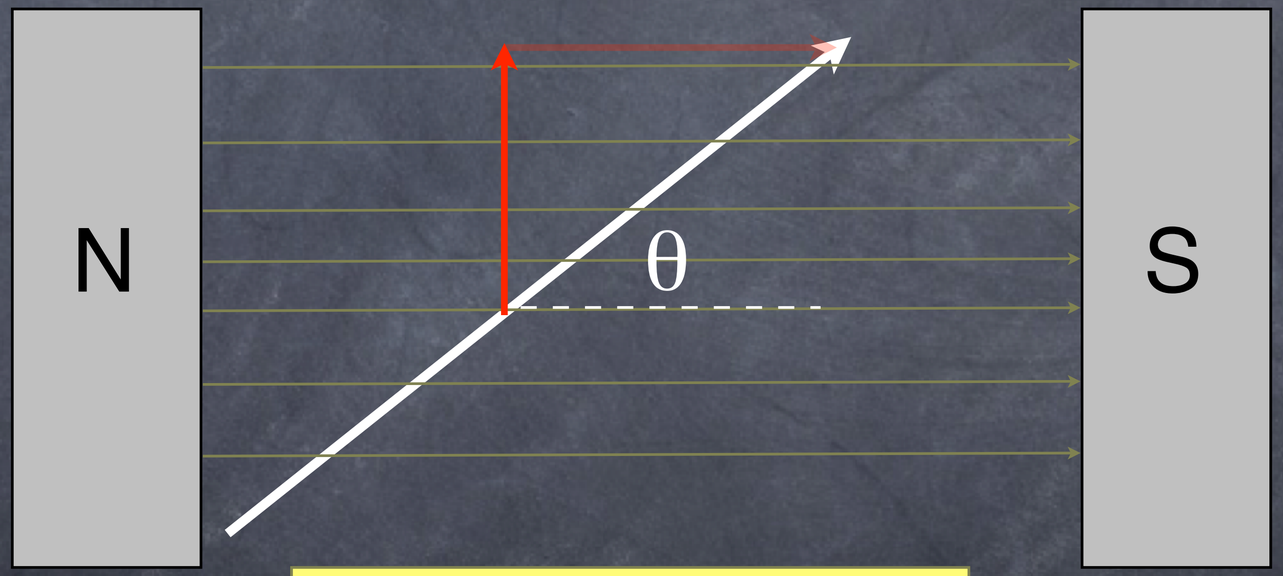
F determined by
B – magnetic field
I – current
L – the length of the wire in the field

Direction determined by RHS Rule

★Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Motor Effect

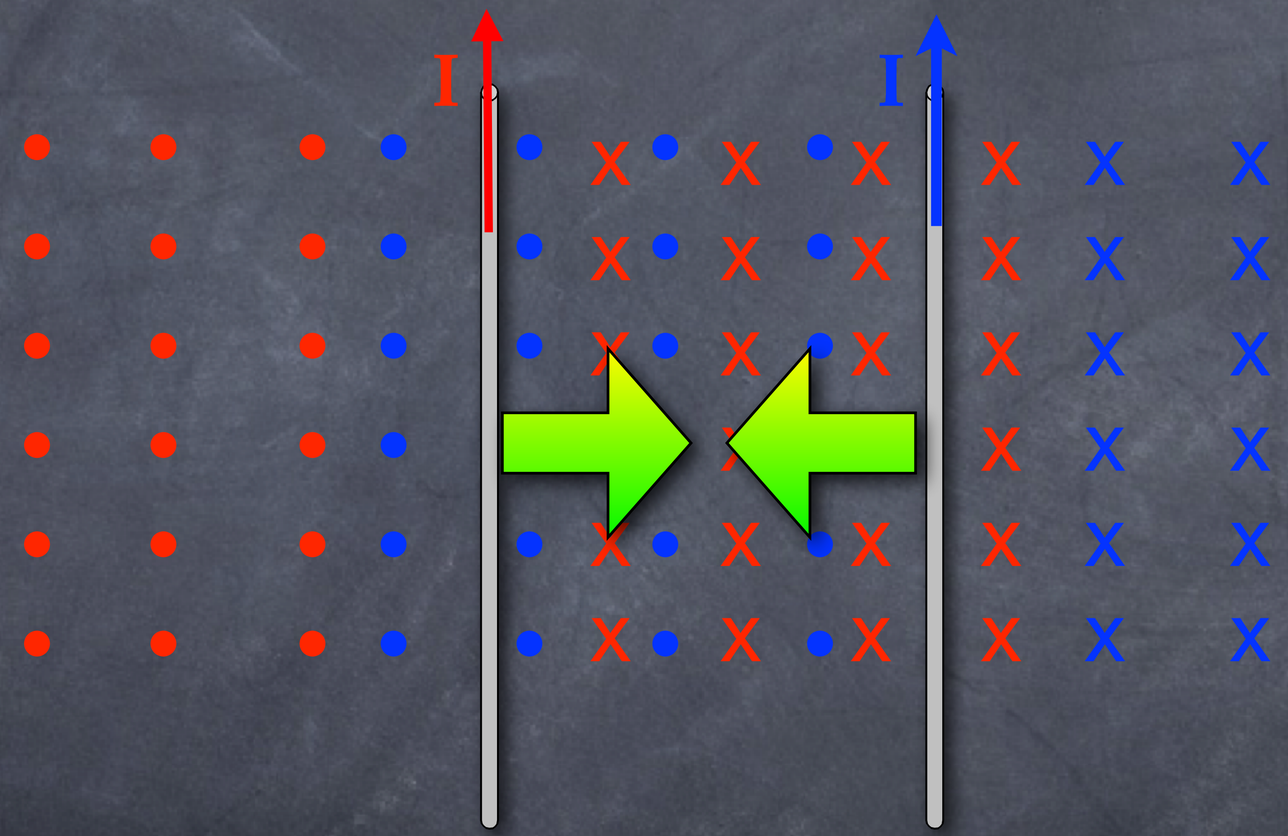
Current must be perpendicular to field for maximum force so,



$$F = BIl\sin(\theta)$$

★Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Motor Effect



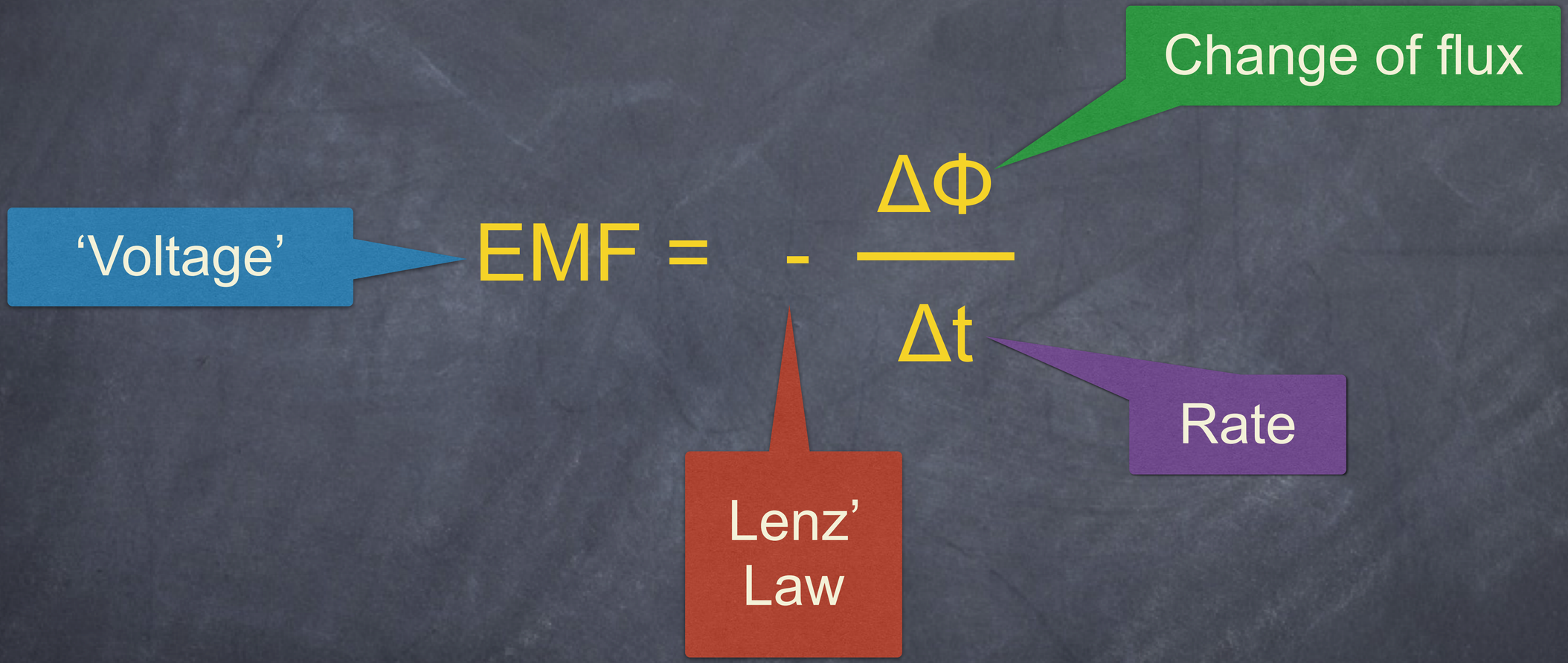
★How are fields related?

Electromagnetic Induction

$$EMF = -\frac{\Delta\Phi}{\Delta t}$$

★How are fields related?

Electromagnetic Induction



Question 33

9 marks

A strong magnet of mass 0.04 kg falls 0.78 m under the action of gravity from position *X* above a hollow copper cylinder. It then travels a distance of 0.20 m through the cylinder from *Y* to *Z* before falling freely again.

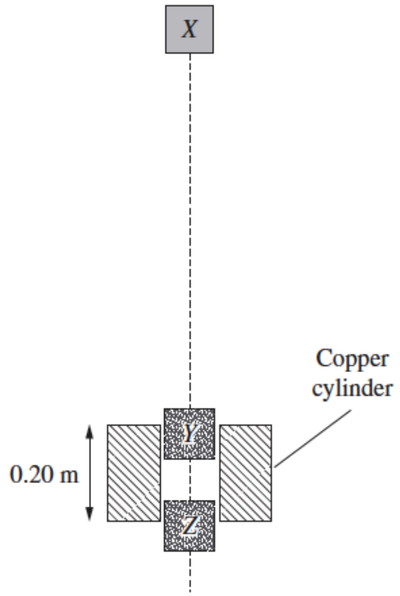
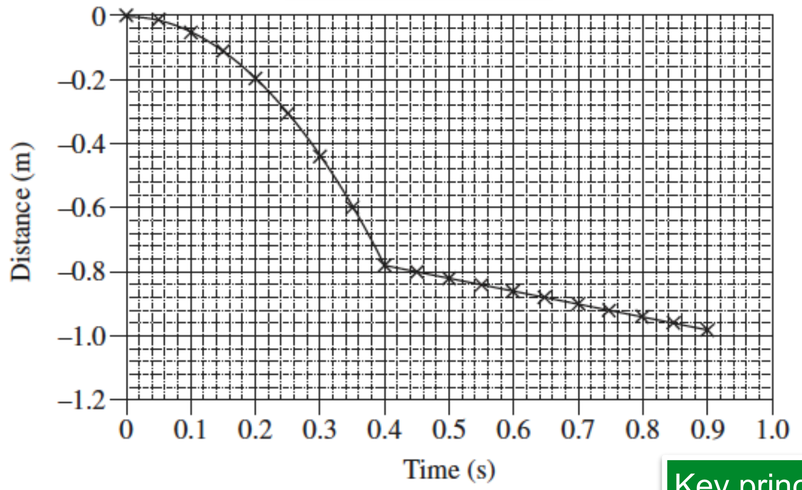


Diagram AND graph

The magnet takes 0.5 seconds to pass through the cylinder. The displacement–time graph of the magnet is shown.

The magnet takes 0.5 seconds to pass through the cylinder. The displacement–time graph of the magnet is shown.

Year 11 assumed



Key principle

Analyse the motion of the magnet by applying the law of conservation of energy.

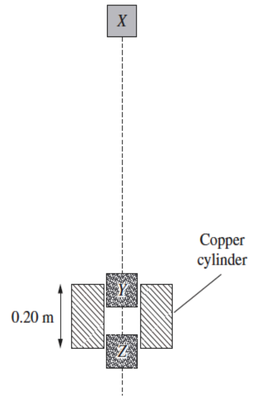
Your analysis should refer to gravity and the copper cylinder, and include both qualitative and quantitative information.

Lots to include

Question 33 2020

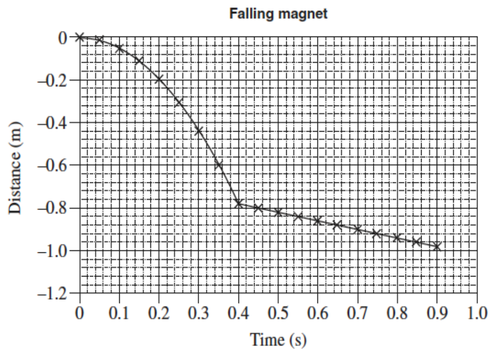
9 marks

A strong magnet of mass 0.04 kg falls 0.78 m under the action of gravity from position *X* above a hollow copper cylinder. It then travels a distance of 0.20 m through the cylinder from *Y* to *Z* before falling freely again.



The magnet takes 0.5 seconds to pass through the cylinder. The displacement–time graph of the magnet is shown.

The magnet takes 0.5 seconds to pass through the cylinder. The displacement–time graph of the magnet is shown.



Analyse the motion of the magnet by applying the law of conservation of energy.

Your analysis should refer to gravity and the copper cylinder, and include both qualitative and quantitative information.

Sample answer:

During the first 0.4 s, the magnet is free-falling due to gravitational force, falling a distance of 0.78 m, and accelerating at 9.8 m s^{-2} $\left(\frac{2s}{t^2}\right)$. Here, gravitational potential energy is being converted to kinetic energy as the magnet accelerates downward. This is shown by the non-linear line on the distance vs time graph.

At position Y, the induced currents in the cylinder produce a magnetic field that causes the magnet to decelerate to a constant velocity of 0.4 m s^{-1} for a period of 0.5 seconds as it passes through the copper cylinder. There is zero net force on the magnet as it passes through the cylinder, as shown by the straight line in the distance vs time graph

The magnet's kinetic energy is converted to heat energy during the deceleration.

As the magnet passes through the cylinder, the gravitational potential energy decreases and there is a corresponding increase in the heat energy in the cylinder. This is consistent with the law of conservation of energy.

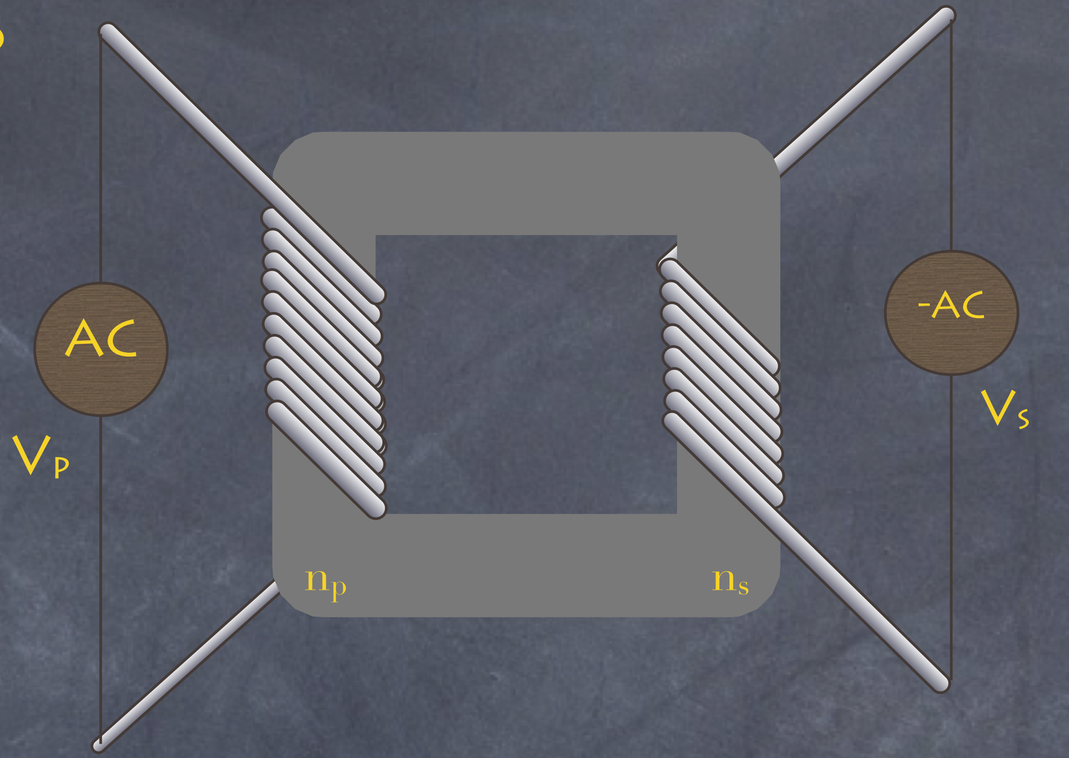
Criteria	Marks
• Provides a comprehensive analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	9
• Provides a thorough analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	8
• Describes the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and/or the copper cylinder • Includes quantitative information	6–7
• Outlines the motion of the magnet AND/OR • Relates the law of conservation of energy AND/OR • Refers to gravity and/or the copper cylinder AND/OR • Includes quantitative information • Shows some understanding of the motion of the magnet and/or gravity and/or the copper cylinder	4–5 2–3
• Provides some relevant information	1

Take home

- How we mark
- Why 9 marks

Transformers

★How are fields related?



$$\frac{V_S}{V_P} = \frac{n_s}{n_p} = \frac{I_P}{I_S}$$

WHY?

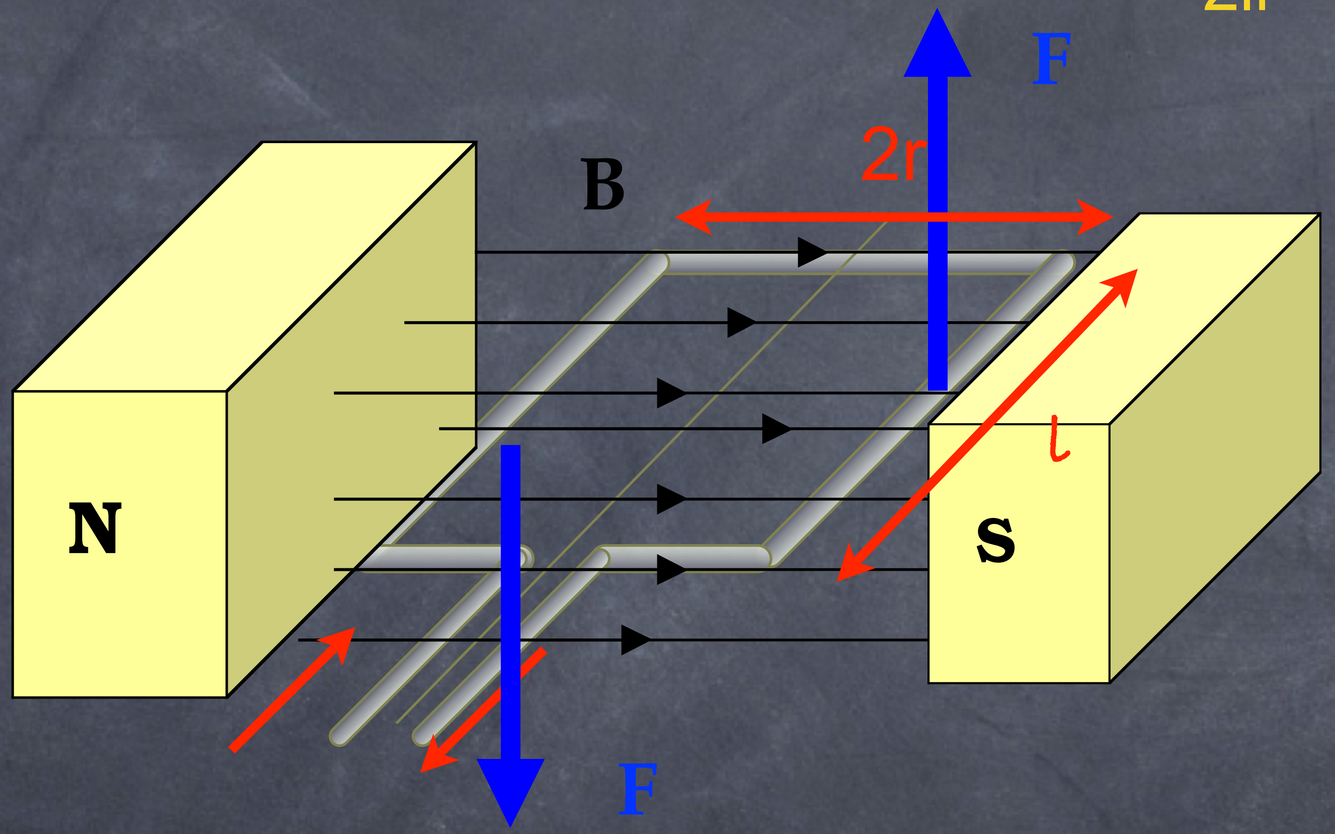
$P_P(=V_P I_P) = P_S\ (=V_S I_S)$

ENERGY IS CONSERVED

★How has knowledge about the Motor Effect been applied to technological advances?

DC motors

2lr = Area

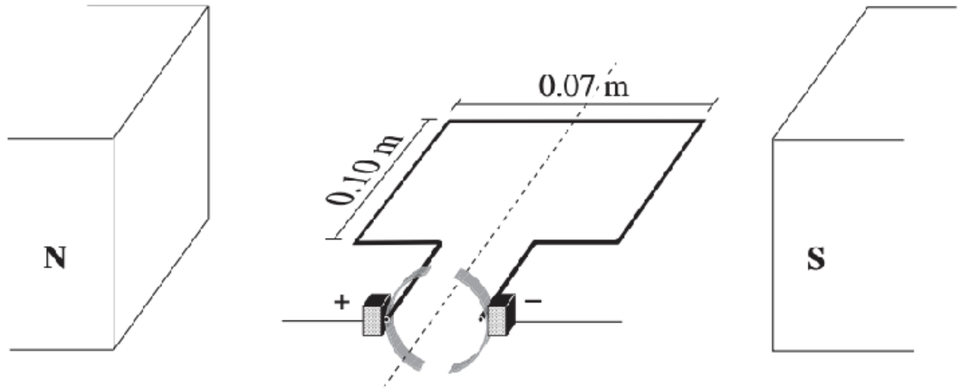


Torque = BAInsinθ where n= number of turns

Question 21a 2021

Question 21 (4 marks)

A DC motor is constructed from a single loop of wire with dimensions 0.10 m × 0.07 m. The magnetic field strength is 0.40 T and a current of 14 A flows through the loop.



(a) Calculate the magnitude of the maximum torque produced by the motor. **2**

Take home

- Show all working

Question 21 (a)

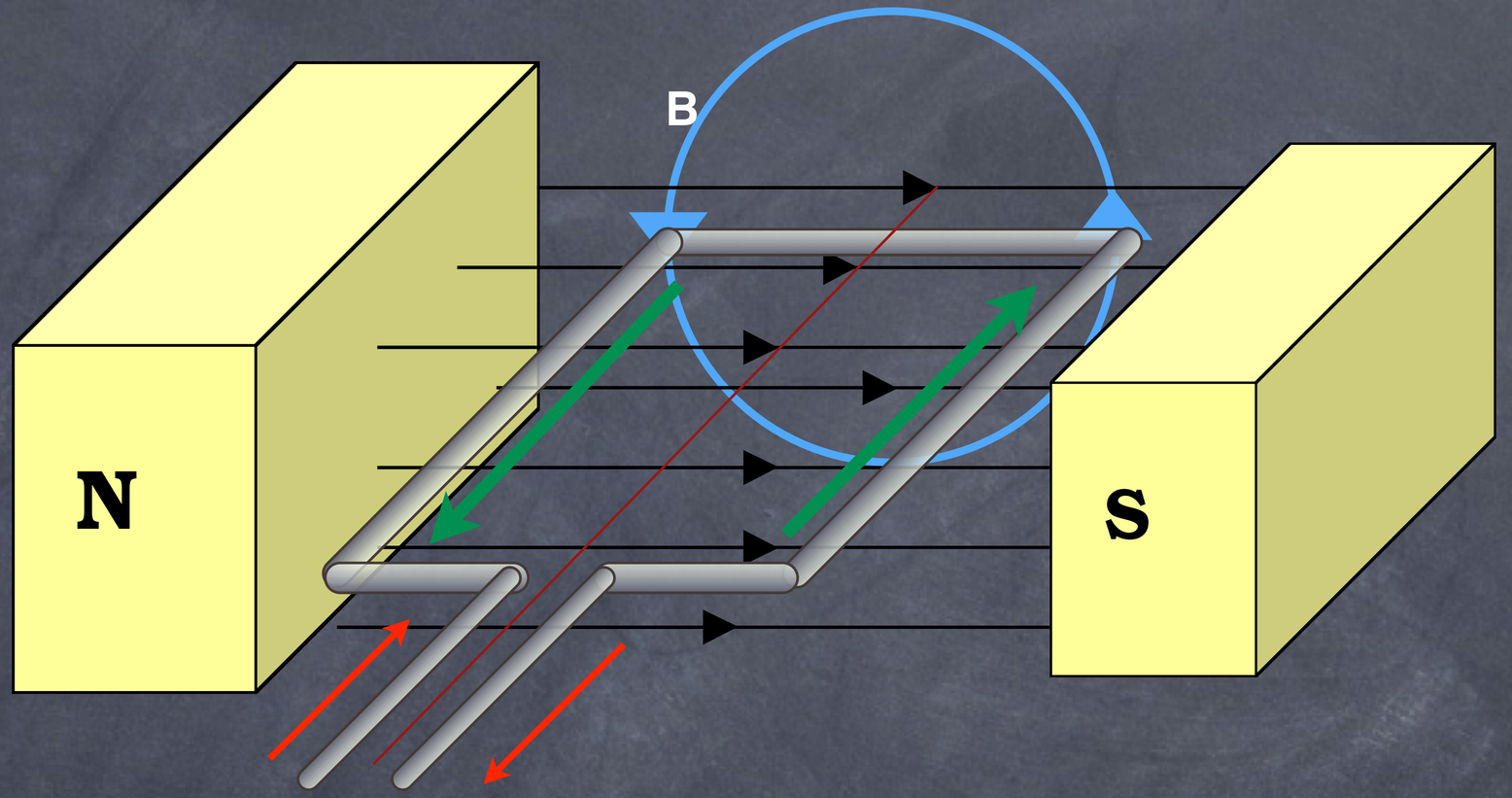
Criteria	Marks
• Correctly calculates the magnitude of the maximum torque	2
• Provides some relevant information	1

Sample answer:

$\tau = nIAB\sin\theta = 1 \times 14 \times 0.1 \times 0.07 \times 0.40 \times \sin(90^{\circ})$

$\tau = 0.04\ Nm$

Self Inductance - back emf

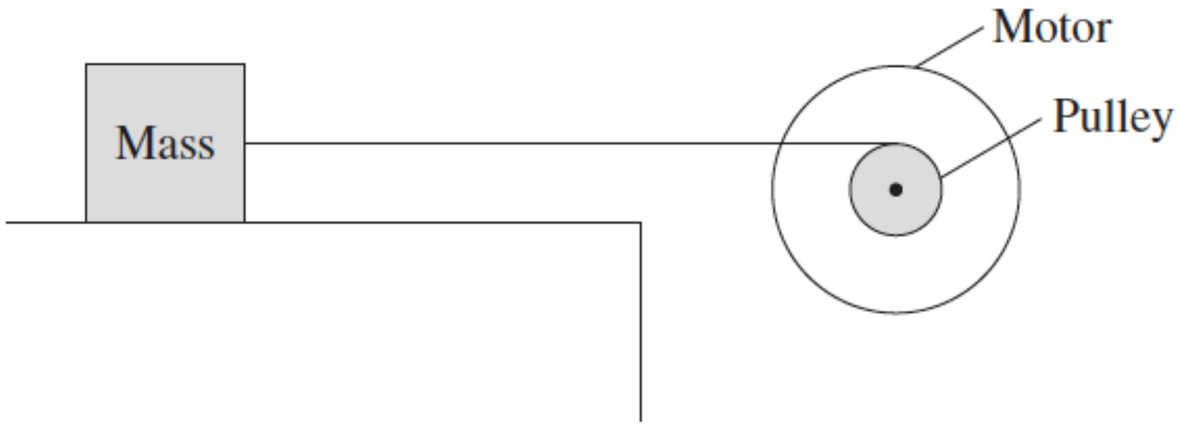


But since it is a coil in a changing flux, what EMF will be produced?

Question 32 2020

7 marks

A rope connects a mass on a horizontal surface to a pulley attached to an electric motor as shown.

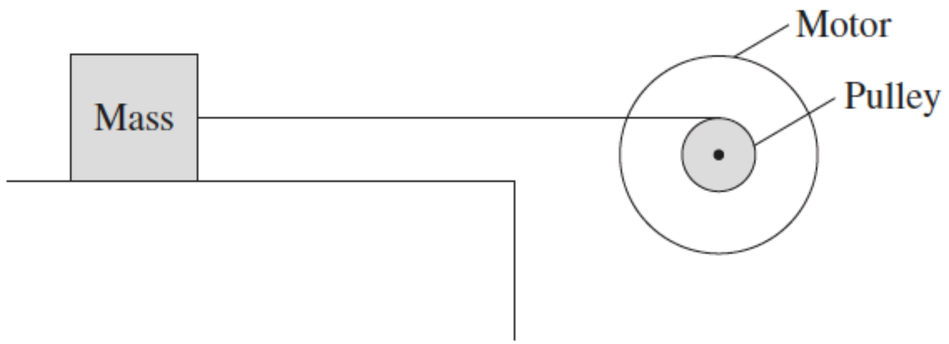


Explain the factors that limit the speed at which the mass can be pulled along the horizontal surface. Use mathematical models to support your answer.

Question 32 2020

7 marks

A rope connects a mass on a horizontal surface to a pulley attached to an electric motor as shown.



Explain the factors that limit the speed at which the mass can be pulled along the horizontal surface. Use mathematical models to support your answer.

Answers could include:

Explanations related to the factors:

- Magnitude of the mass
- Friction between the block and the table (related to mass and coefficient of friction)
- Back emf in the motor
- Power input to the motor
- Diameter of the pulley
- Torque produced
- Motor efficiency.

Mathematical models could include:

- $F - ma$
- $P - VI$
- $F_f - \mu N$
- $\tau = rF\sin\theta$.

Criteria	Marks
• Provides a comprehensive explanation of the relevant factors • Supports the answer with mathematical models	7
• Provides explanations of relevant factors • Supports the answer with at least one mathematical model	6
• Describes some relevant factors and provides some explanation • Refers to at least one mathematical model	5
• Outlines relevant factor(s) and/or mathematical model(s)	3–4
• Outlines a relevant factor OR • Identifies relevant factors and/or features of a mathematical model	2
• Provides some relevant information	1

Take home

- Plan responses

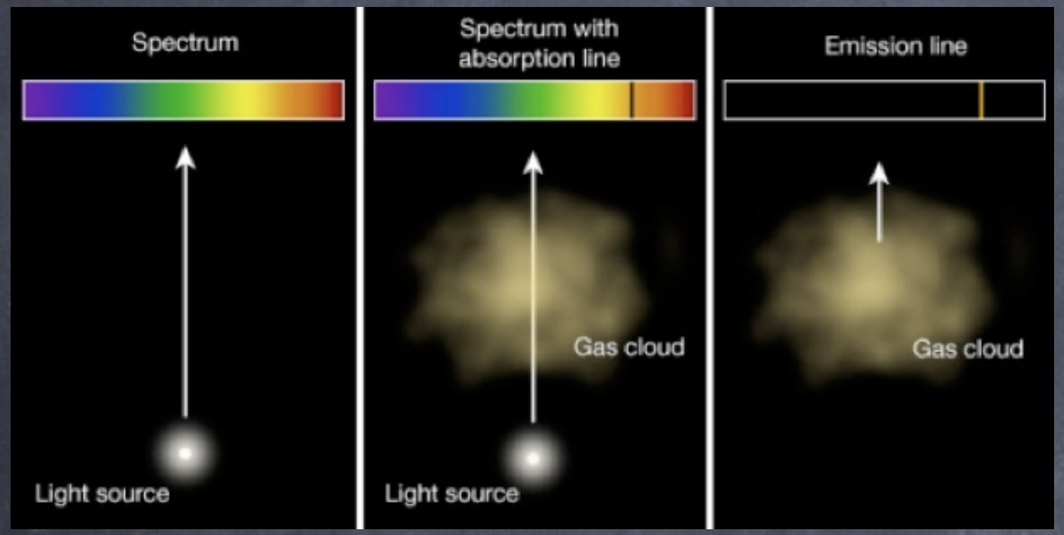
Module 7

The Nature of Light

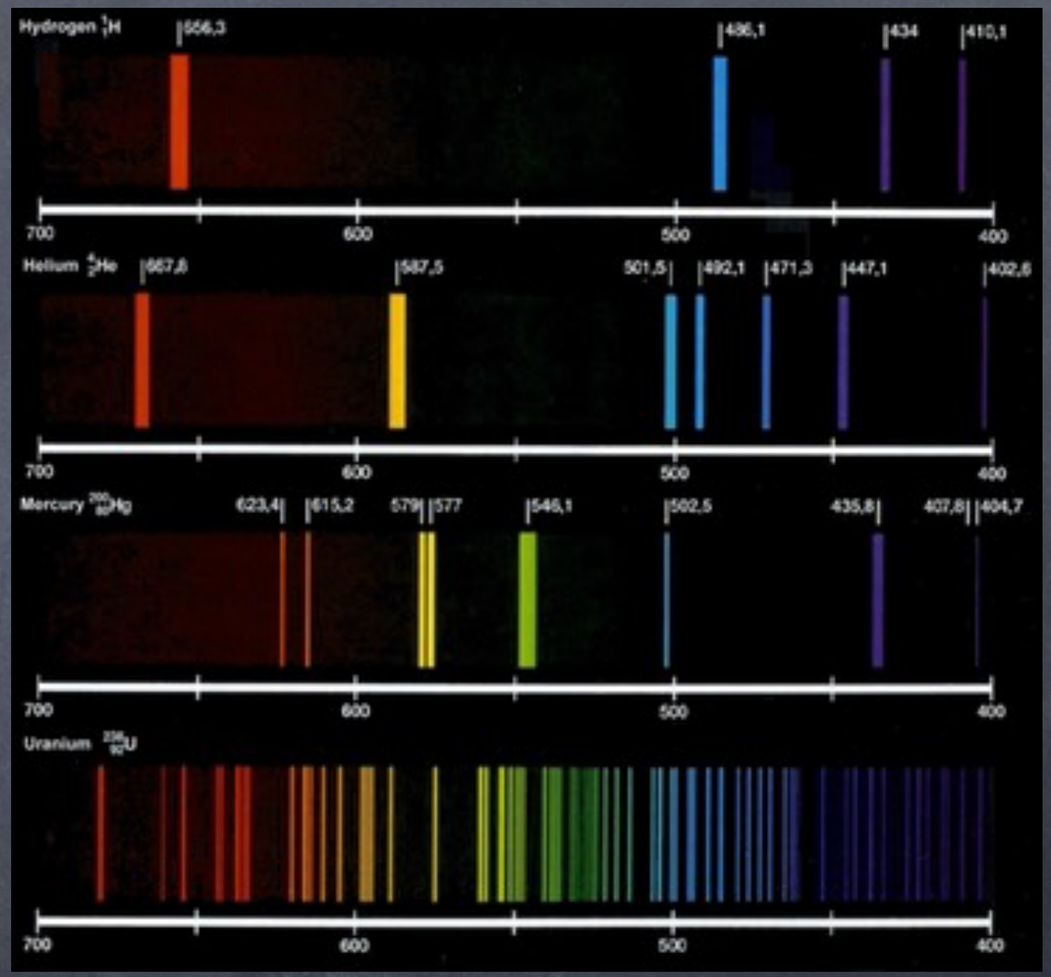
4 inquiry questions

- What is light?
- What evidence supports the classical wave model of light and what predictions can be made using this model?
- What evidence supports the particle model of light and what are the implications of this evidence for the development of the quantum model of light?
- How does the behaviour of light affect concepts of time, space and matter?

★What is light?



Spectroscopy



★What is light?

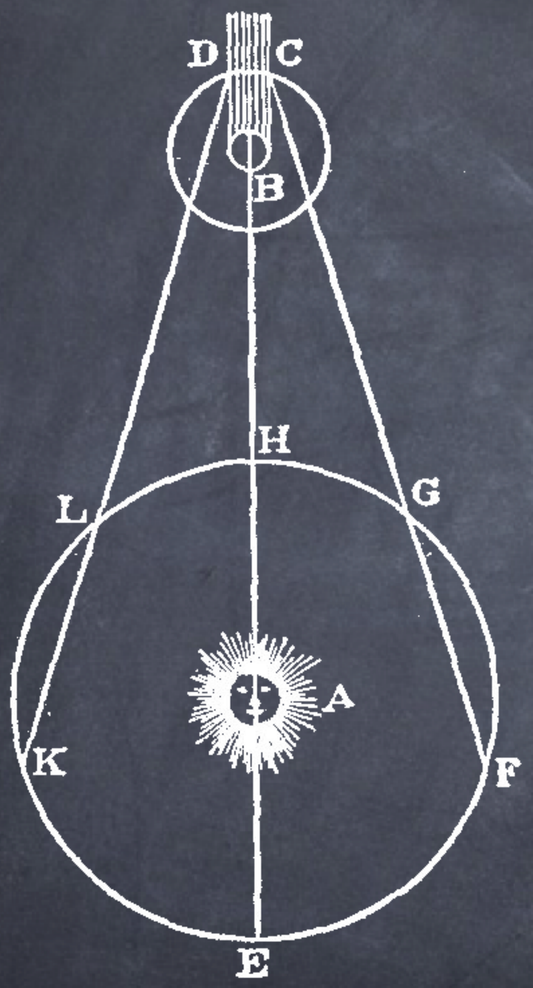
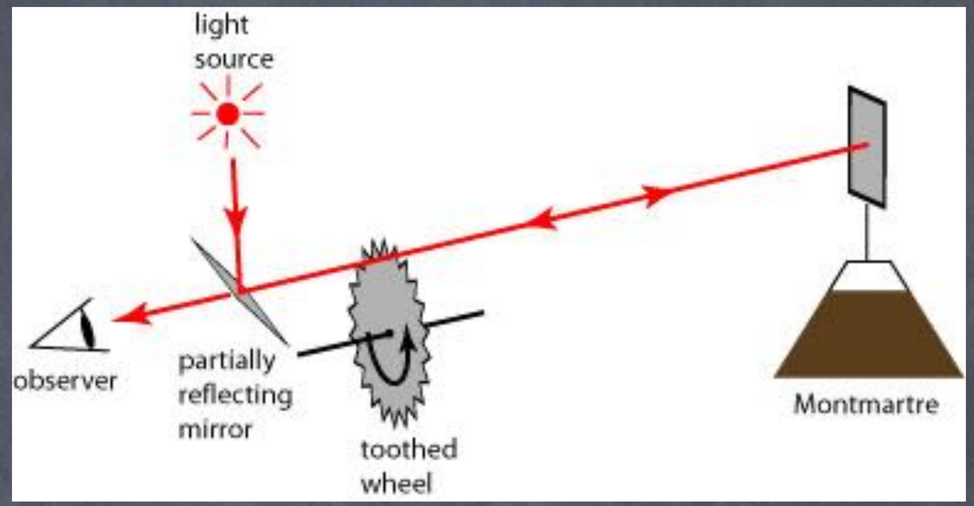
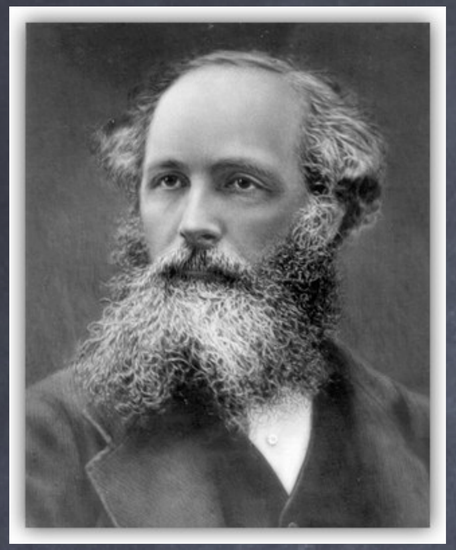


Fig. 70.



Measuring its speed



Maxwell

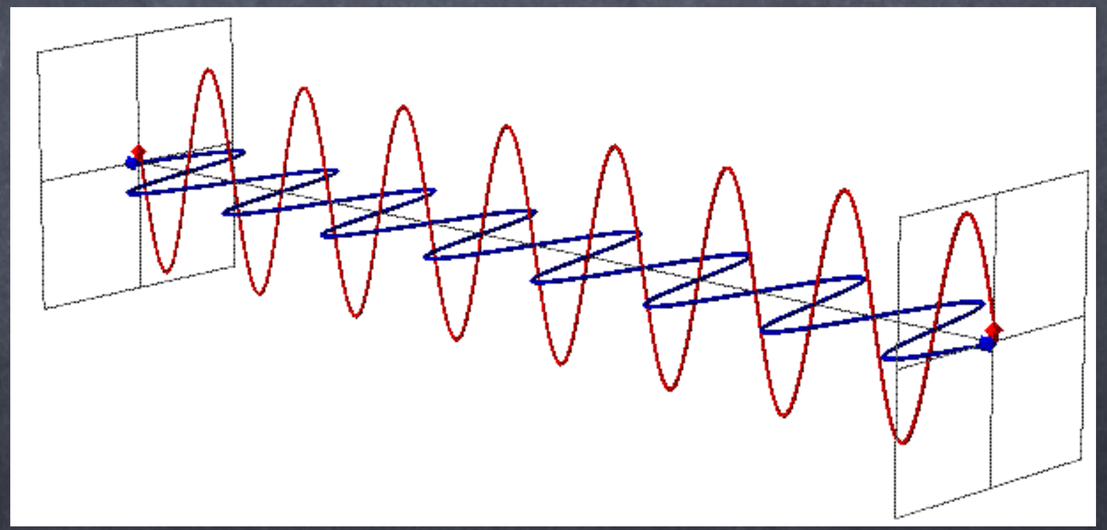
★What is light?

$$\nabla \cdot \mathbf{D} = \rho$$

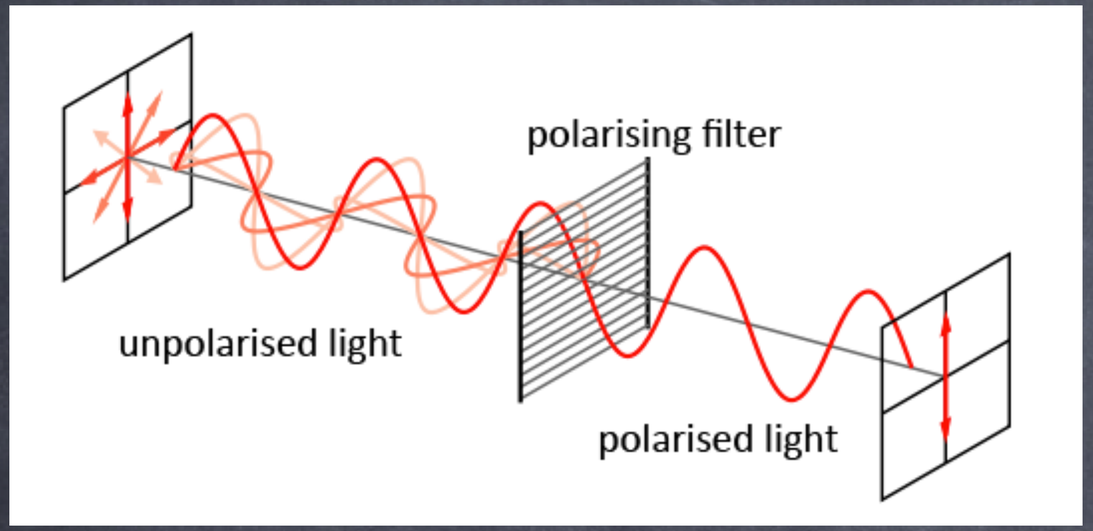
$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

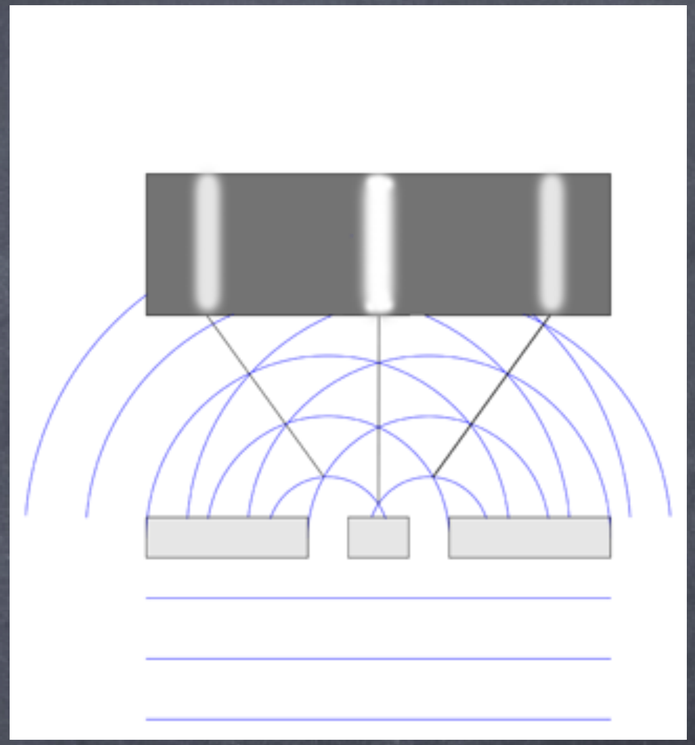
$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$



★What evidence supports the classical wave model of light and what predictions can be made using this model?

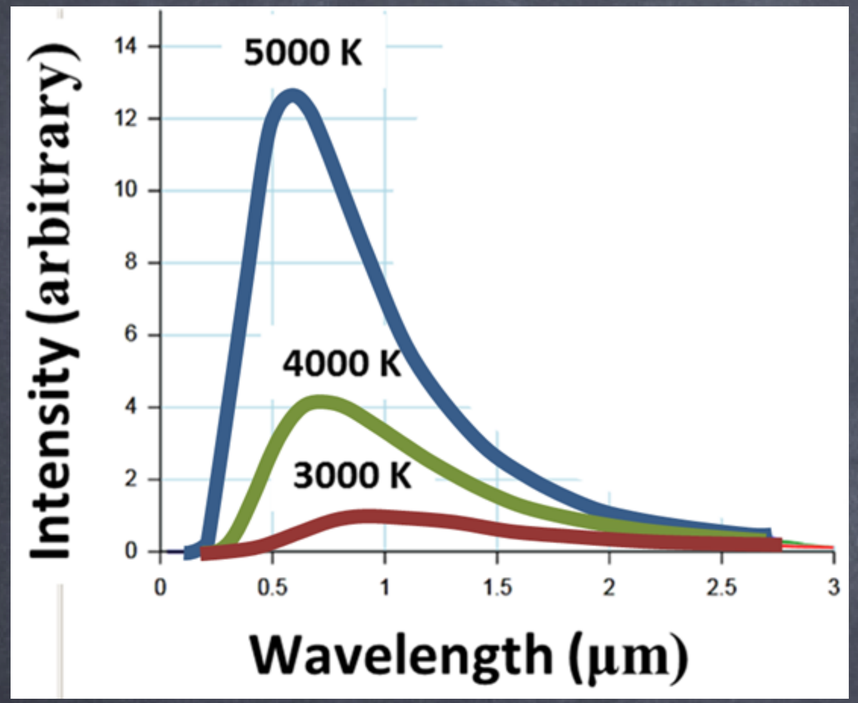


$I = I_0 \cos^2\theta$

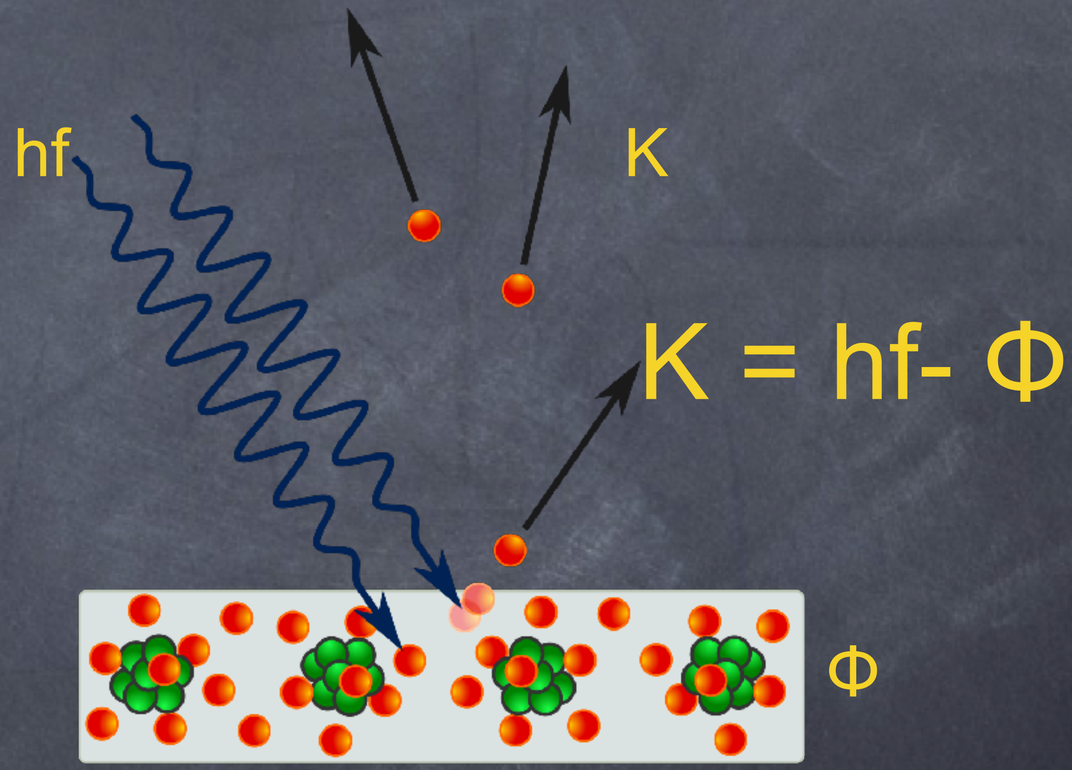


$m\lambda = d\sin\theta$

★What evidence supports the particle model of light and what are the implications of this evidence for the development of the quantum model of light?



Blackbody radiation



Photoelectric effect

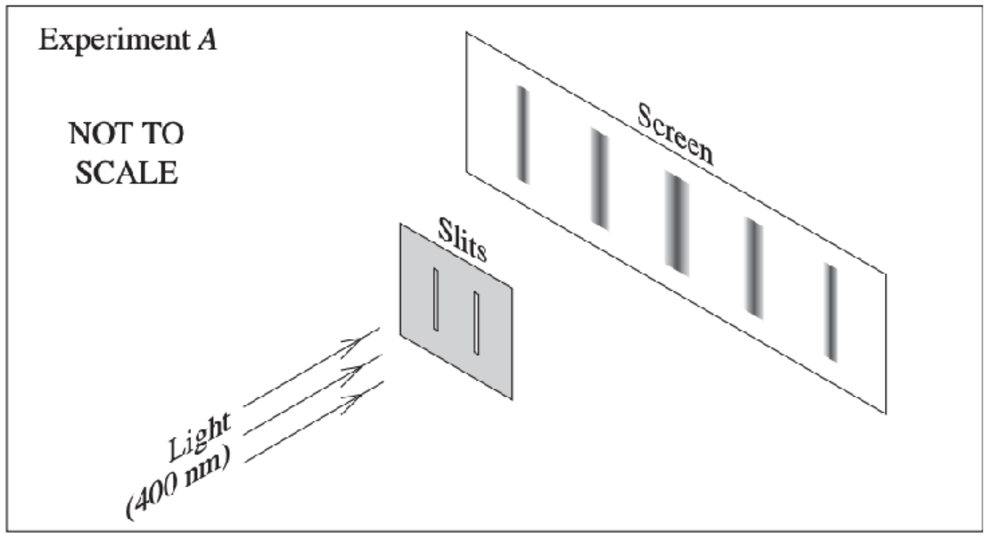
Question 33

9 marks

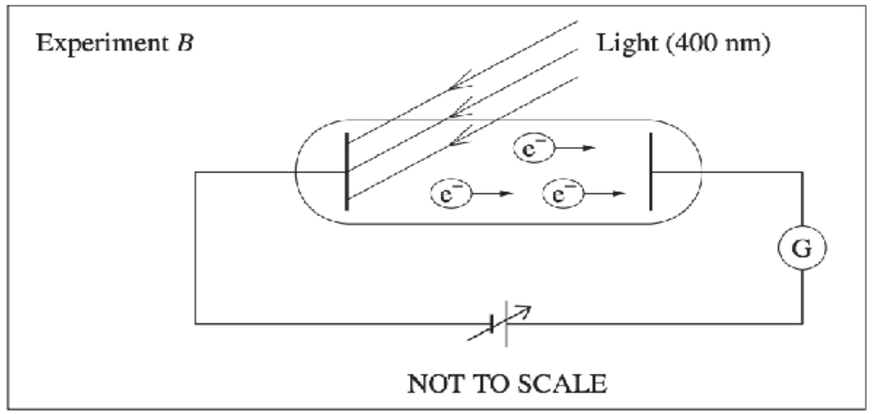
Question 33 (9 marks)

Two experiments are performed with identical light sources having a wavelength of 400 nm. **9**

In experiment *A*, the light is incident on a pair of narrow slits 5.0×10^{-5} m apart, producing a pattern on a screen located 3.0 m behind the slits.



In experiment *B*, the light is incident on different metal samples inside an evacuated tube as shown. The kinetic energy of any emitted photoelectrons can be measured.



Some results from experiment *B* are shown.

Metal sample	*Work function* (J)	*Photoelectrons observed?*
Nickel	8.25×10^{-19}	No
Calcium	4.60×10^{-19}	Yes

How do the results from Experiment *A* and Experiment *B* support TWO different models of light? In your answer, include a quantitative analysis of each experiment.

Question 33

9 marks

Question 33

Criteria	Marks
• Provides comprehensive quantitative analysis of each experiment • Shows a comprehensive understanding of how results from the experiments support two different models of light	9
• Provides quantitative analysis of each experiment • Shows a thorough understanding of how results from the experiments support two different models of light	8
• Provides aspects of quantitative analysis of each experiment • Relates the experiments to two different models of light	6–7
• Provides aspects of analysis of experiment(s) • Provides information about relevant models of light	4–5
• Provides information about relevant model(s) of light AND/OR • Includes quantitative information	2–3
• Provides some relevant information	1

Take home

- Use all the stimulus

Sample answer:

In Experiment *A*, a pattern of bright and dark regions will be observed on the screen. The spacing between adjacent regions can be calculated:

$$d\sin\theta = m\lambda$$

$$5 \times 10^{-5}\sin\theta = 1 \times 400 \times 10^{-9}$$

$$\theta = 0.46^{\circ}$$

$$s = 3 \times \tan 0.46 = 0.024 \text{ m}$$

The pattern is explained by the wave model where light waves from the slits arrive at the screen causing bright regions at points of constructive interference and dark regions at points of destructive interference. This supports the wave model of light.

In Experiment *B*, photoelectrons are emitted from calcium but not nickel. The particle model of light can be used to calculate the photon energy of incident light:

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}}{400 \times 10^{-9}} = 7.50 \times 10^{14} Hz$$

$$E = hf = 6.626 \times 10^{-34} \times 7.50 \times 10^{14} = 4.97 \times 10^{-19} J$$

This energy is higher than the work function of calcium but not nickel, explaining why one photon has enough energy to liberate a photo electron from the calcium sample, supporting the particle model of light. The particle model can be further applied to calculate the kinetic energy of photoelectrons emitted from the calcium sample.

$$K_{max} = hf - \phi = 4.97 \times 10^{-19} - 4.60 \times 10^{-19} = 3.70 \times 10^{-20} J$$

★How does the behaviour of light affect concepts of time, space and matter?

postulates

consequences

evidence

inertial reference frames equivalent
c is constant for all

- time dilation → Hafele Keating; muon detection
- Length contraction → muon detection
- momentum dilation → Particle accelerators
- Energy mass equivalence → Particle accelerators; Radioactivity

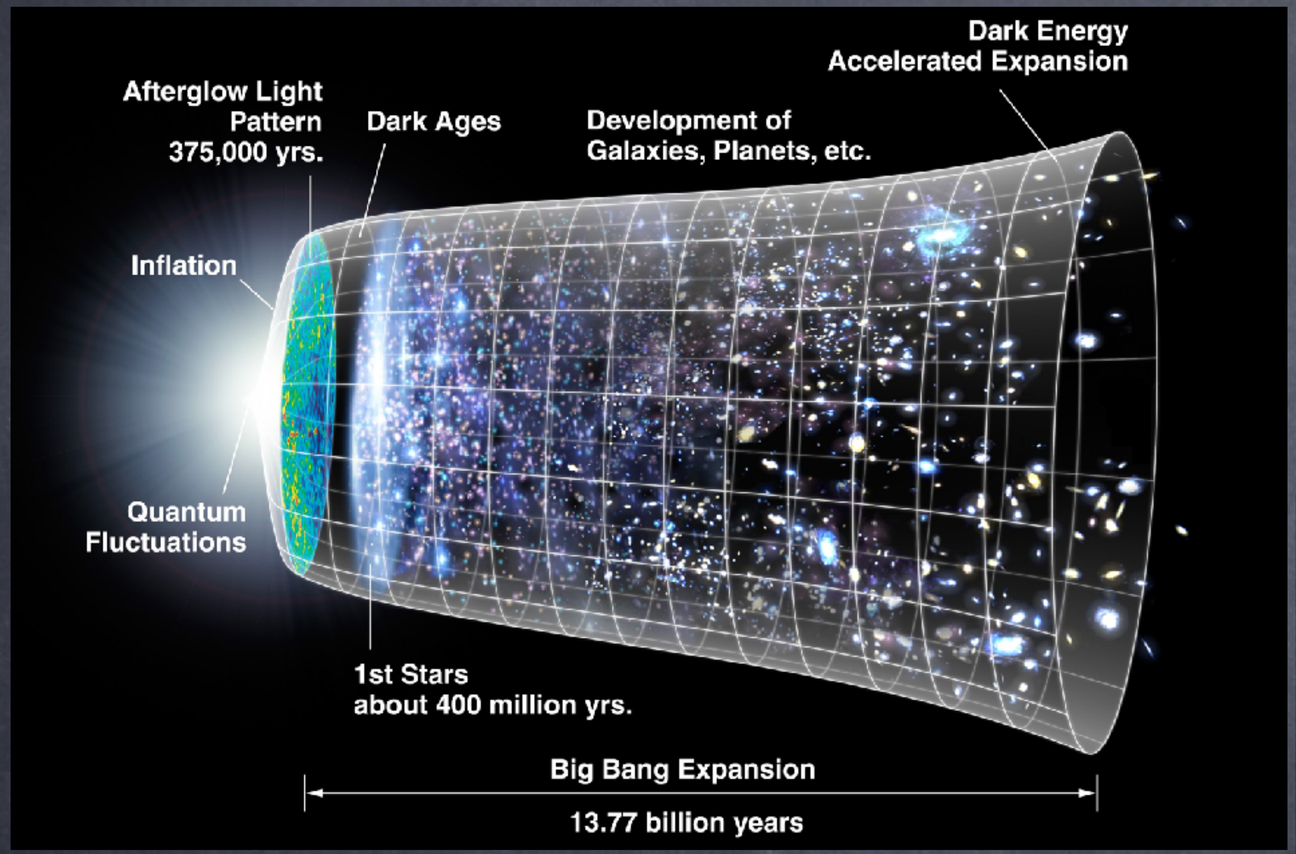
Module 8

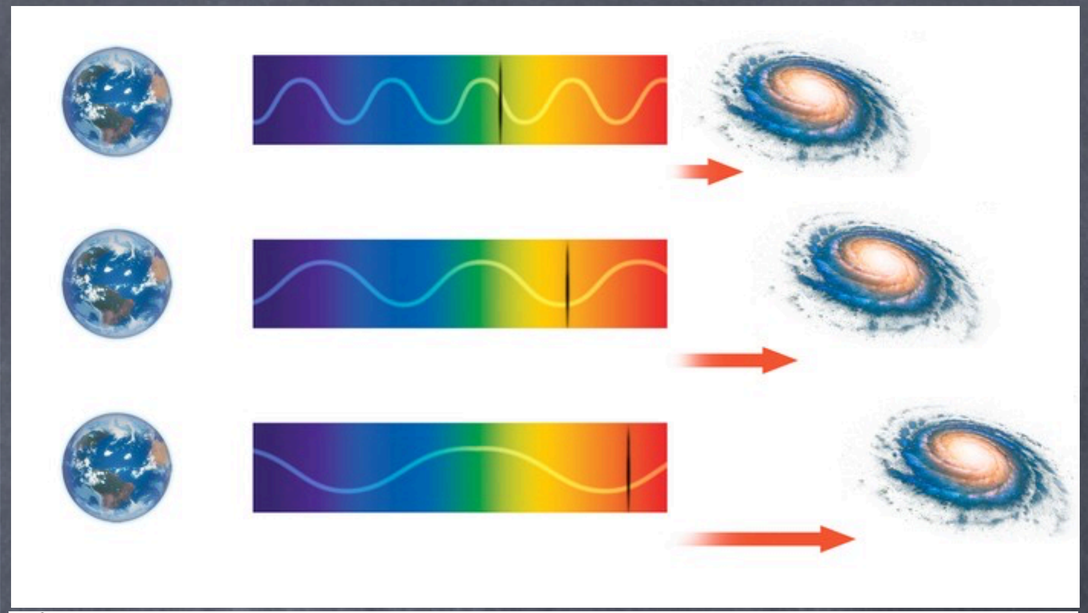
The Universe to the Atom

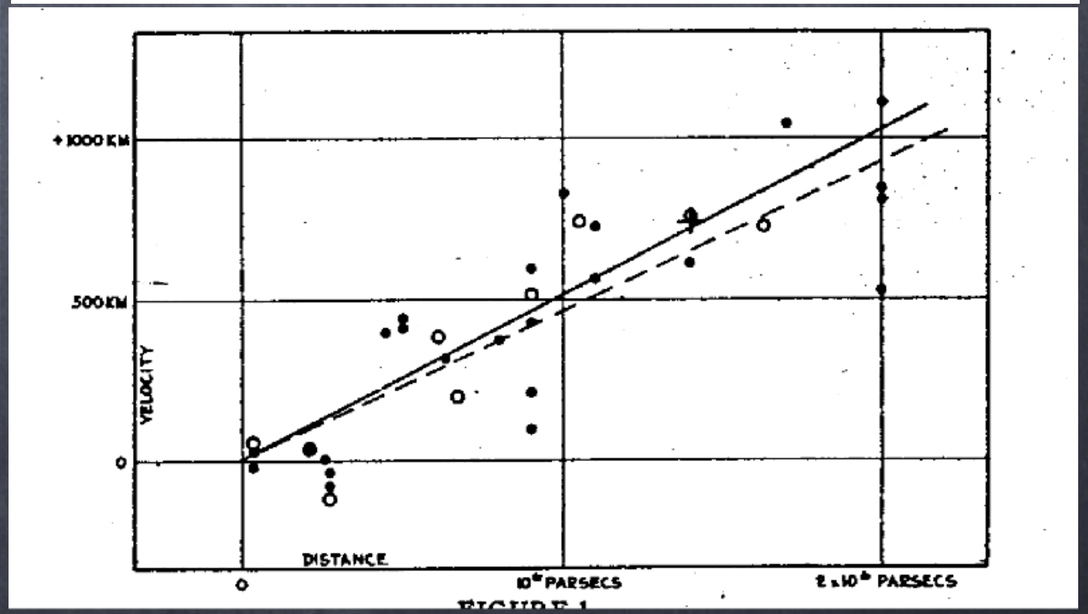
5 inquiry questions

- What evidence is there for the origins of the elements?
- How is it known that atoms are made up of protons, neutrons and electrons?
- How is it known that classical physics cannot explain the properties of the atom?
- How can the energy of the atomic nucleus be harnessed?
- How is it known that human understanding of matter is still incomplete?

★What evidence is there for the origins of the elements?







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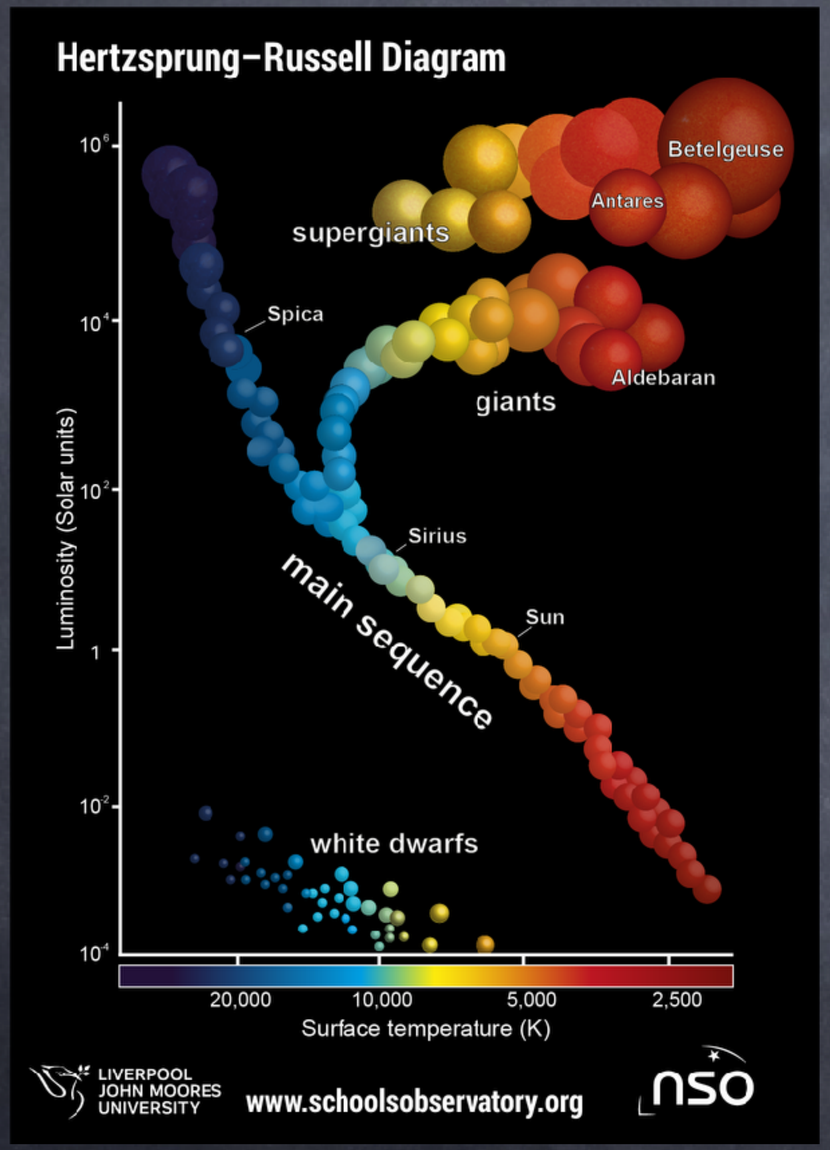
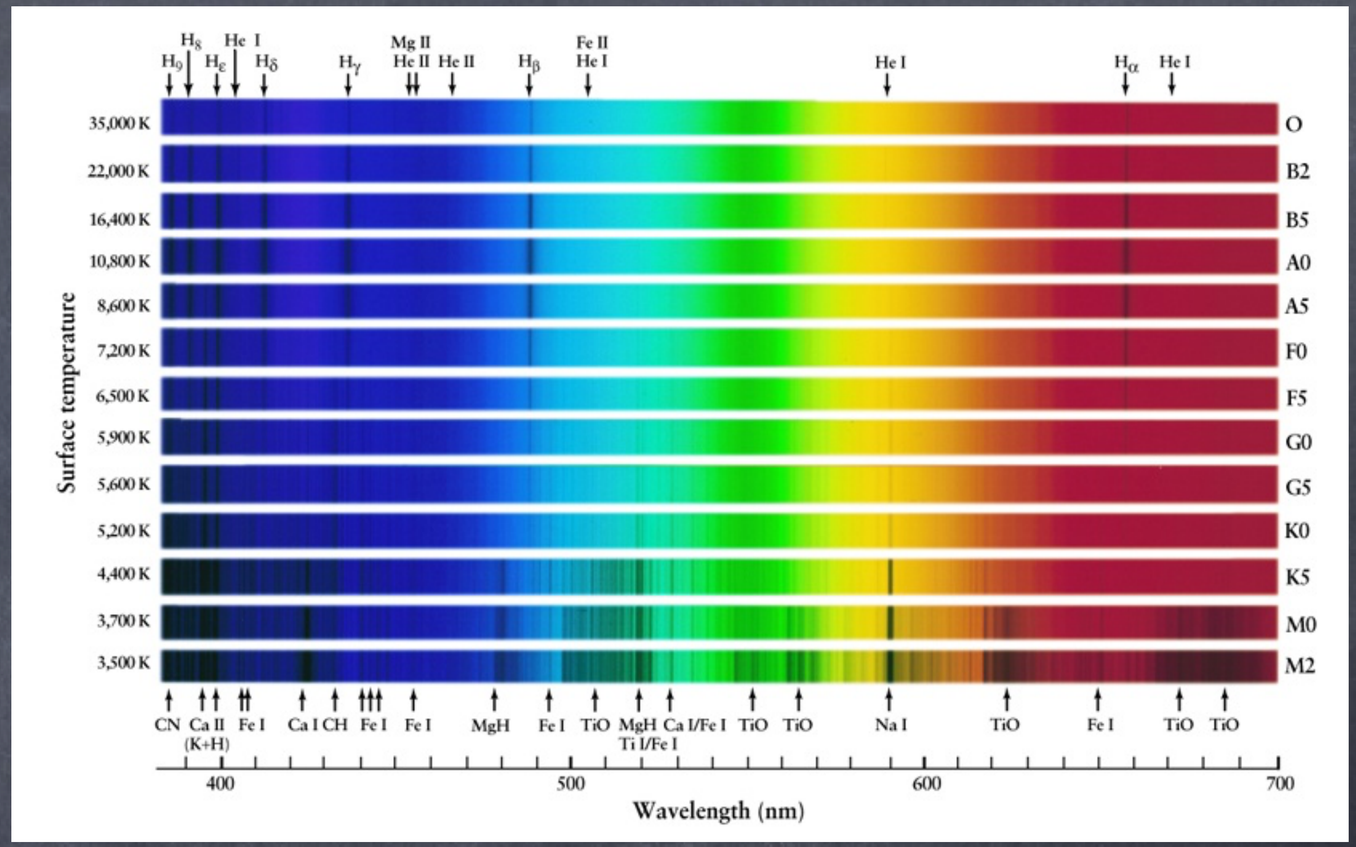
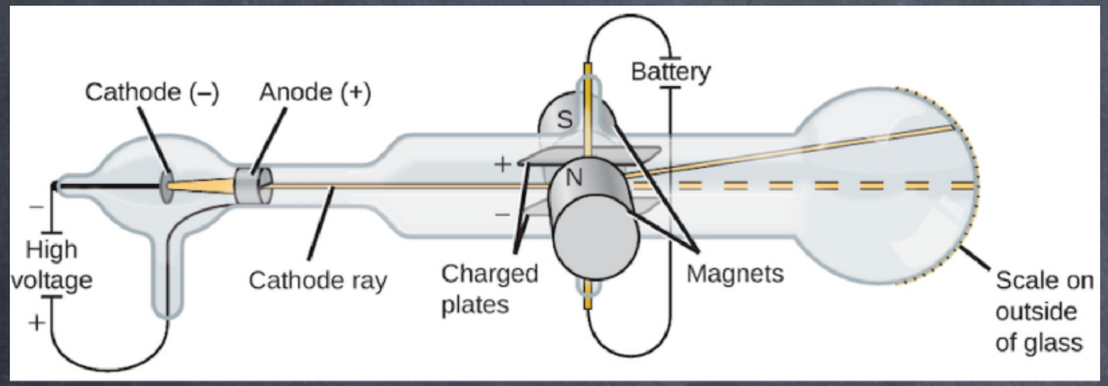




★How is it known that atoms are made up of protons, neutrons and electrons?

- JJ Thompson - determine charge to mass ratio of electron



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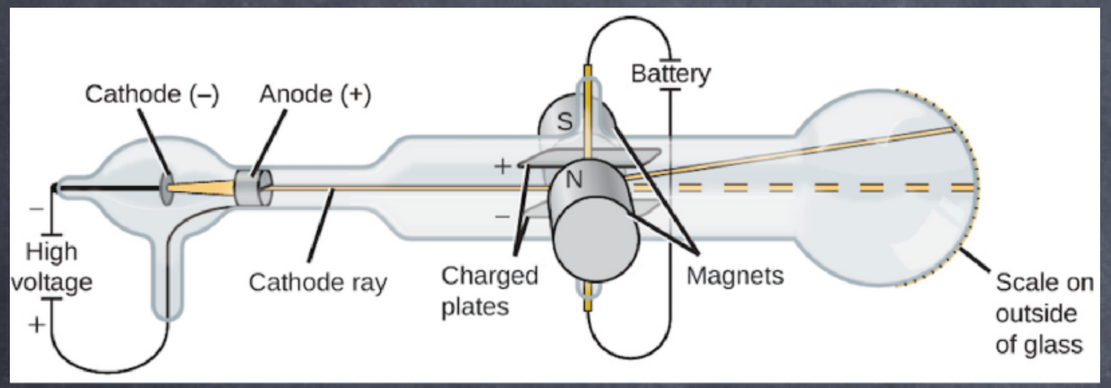

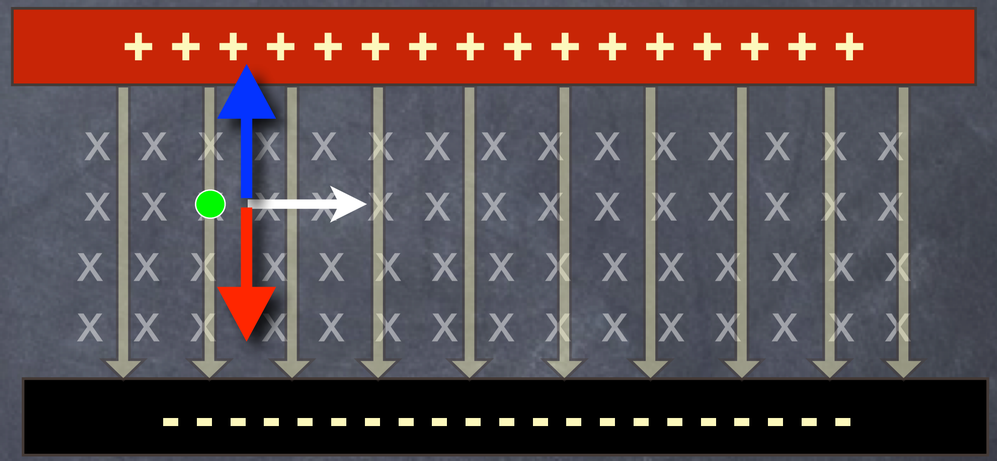

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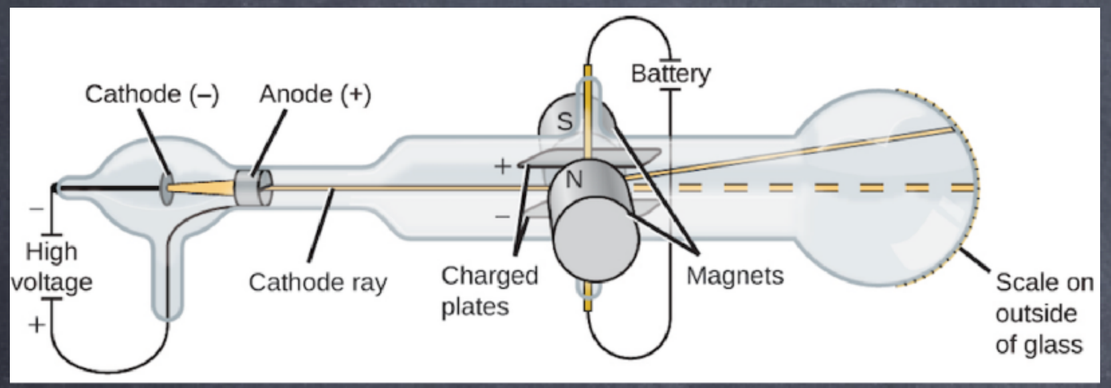
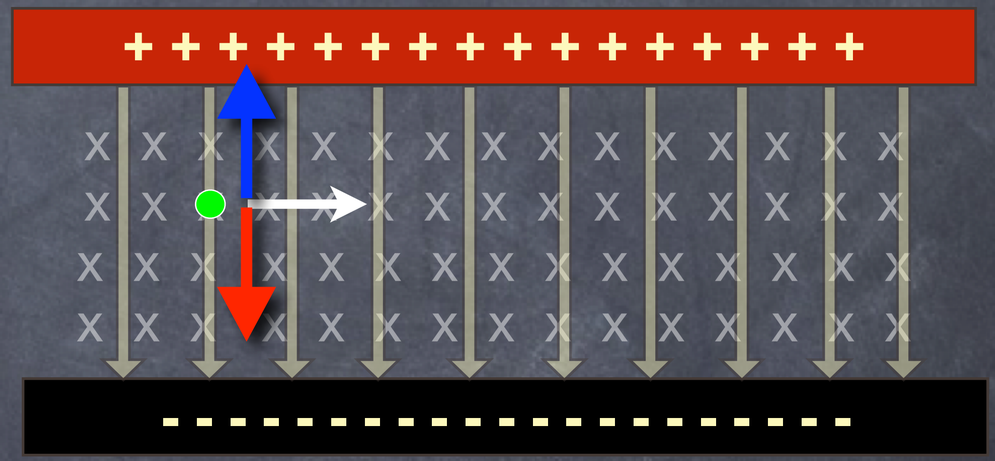
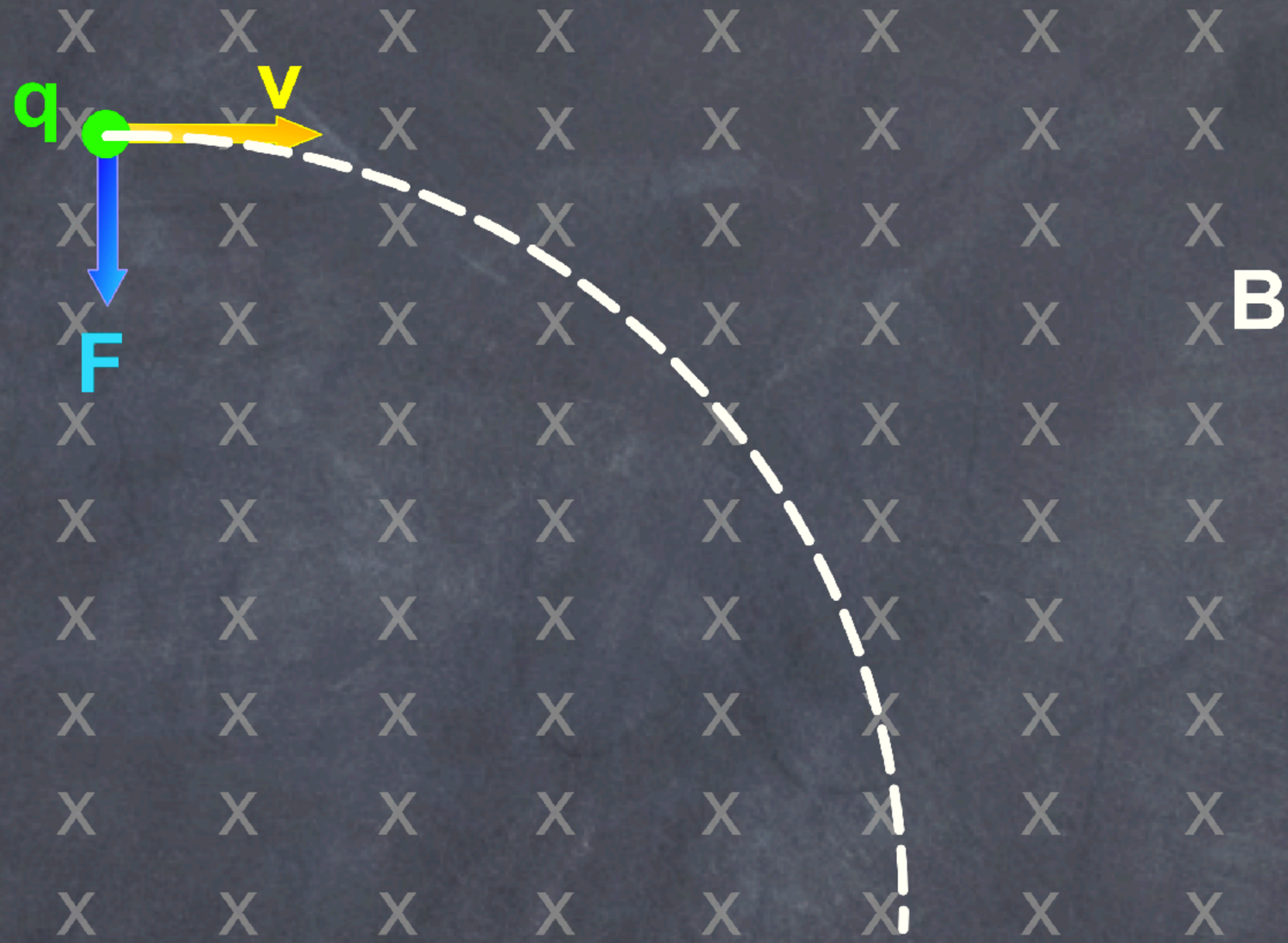




$F_B = F_E$

$qvB = Eq$

$v = E / B$



$F_B = F_C$

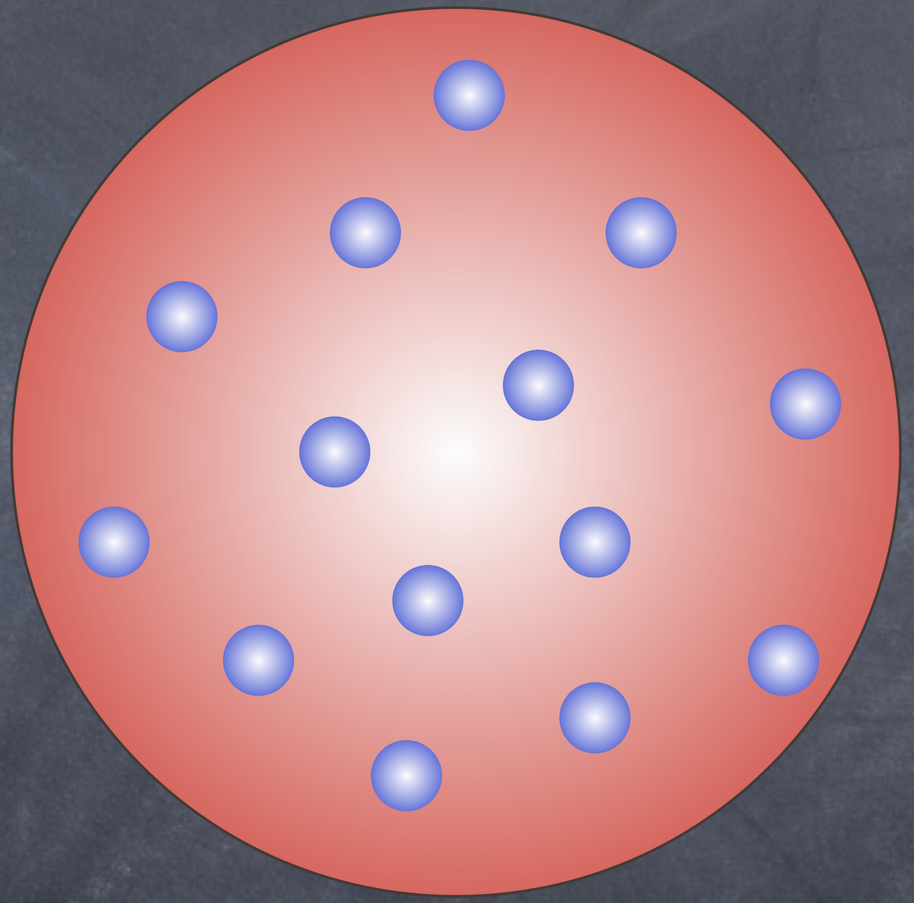
$$Bqv = \frac{mv^2}{r}$$

$$Bq = \frac{mv}{r}$$

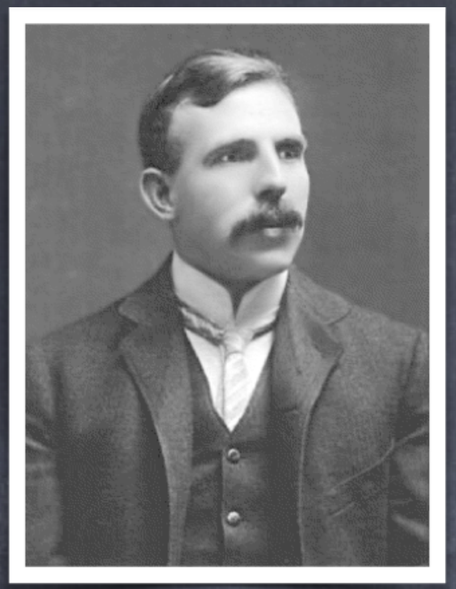
$$\frac{q}{m} = \frac{v}{Br}$$

- JJ Thompson - determine charge to mass ratio of electron

- How is it known that atoms are made up of protons, neutrons and electrons?



Plum pudding model



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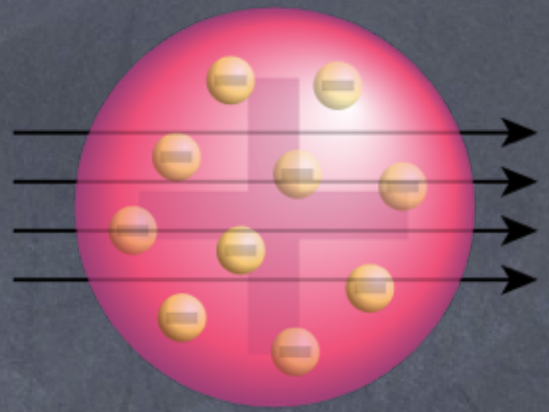
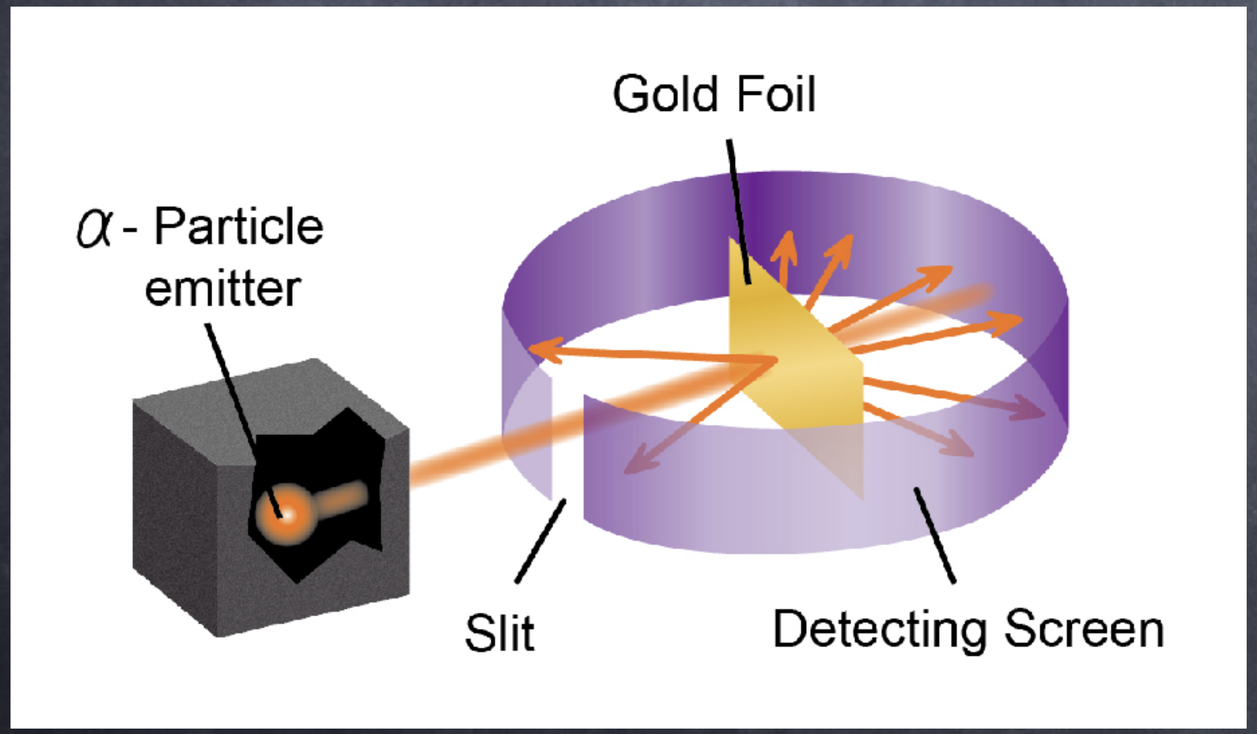
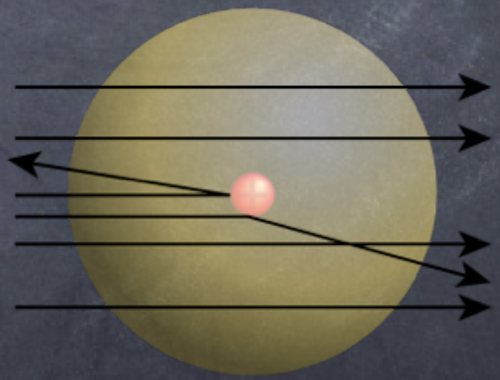
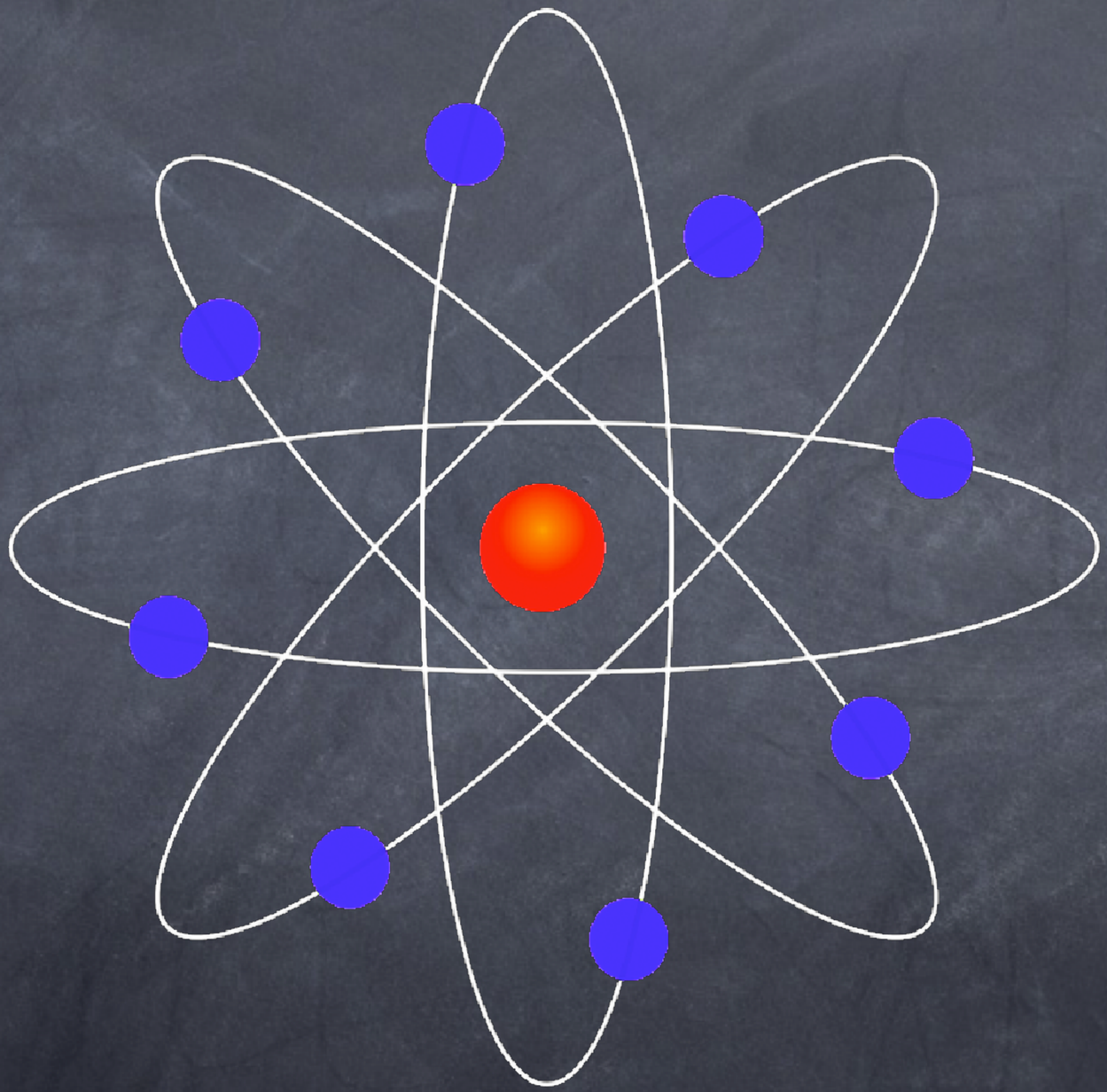




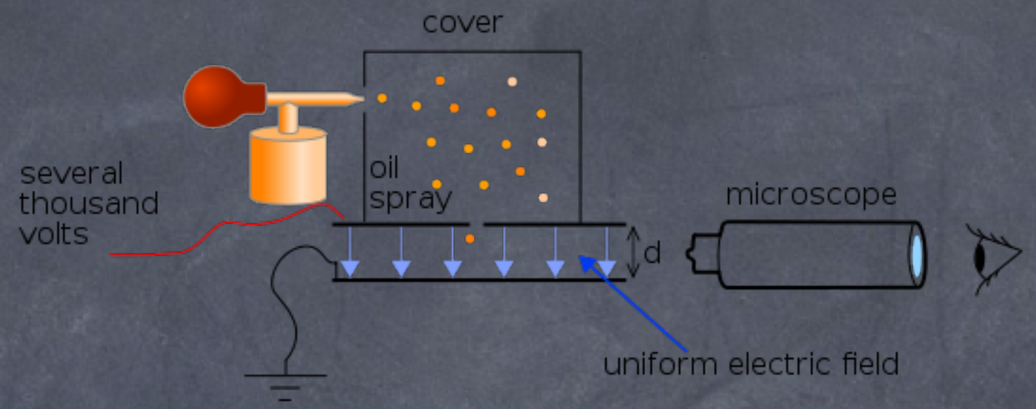


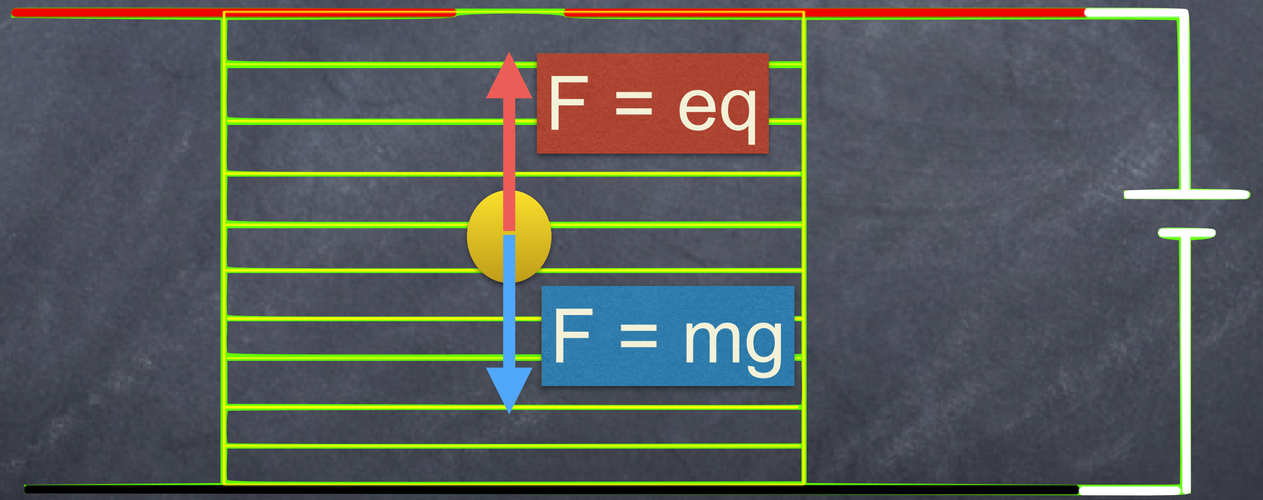
- How is it known that atoms are made up of protons, neutrons and electrons?



★How is it known that atoms are made up of protons, neutrons and electrons?

Millikan





Question 23 2021

Question 23 (4 marks)

Describe how Millikan and Thomson each used fields to determine properties of the electron. **4**

Interpret the question

Question 23 2021

Question 23 (4 marks)

Describe how Millikan and Thomson each used fields to determine properties of the electron. **4**

Question 23 2021

Question 23 (4 marks)

Describe how Millikan and Thomson each used fields to determine properties of the electron. **4**

Take home

- Different types of fields
- Address the verb

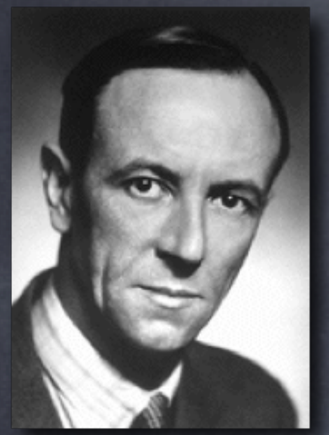
Question 23

Criteria	Marks
• Provides a thorough description of the use of fields by Thomson and Millikan to determine properties of the electron	4
• Provides some description of the use of fields by Thomson and Millikan to determine properties of the electron OR • Provides a thorough description of the use of fields by either Thomson or Millikan to determine properties of the electron	3
• Shows some understanding of the use of fields by Thomson and/or Millikan to study the electron	2
• Provides some relevant information	1

Sample answer:

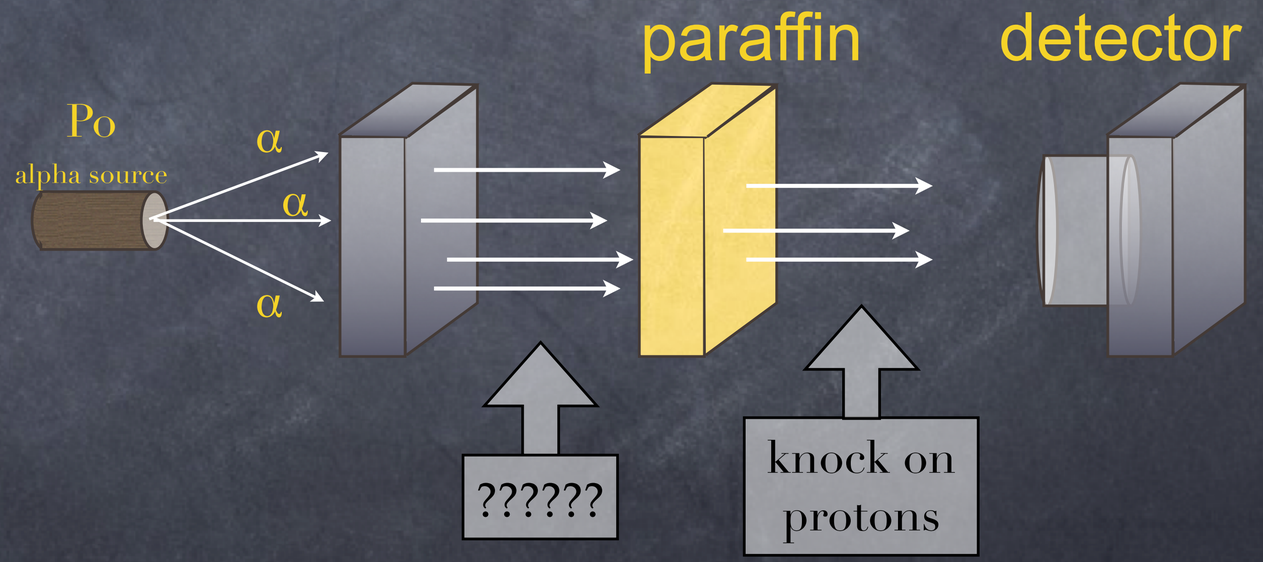
Thomson used electric and magnetic fields to balance forces on electrons, allowing him to calculate the charge to mass ratio of electrons. Millikan used electric and gravitational fields to levitate charged droplets, allowing him to determine the charge on the electron.

★How is it known that atoms are made up of protons, neutrons and electrons?



Chadwick

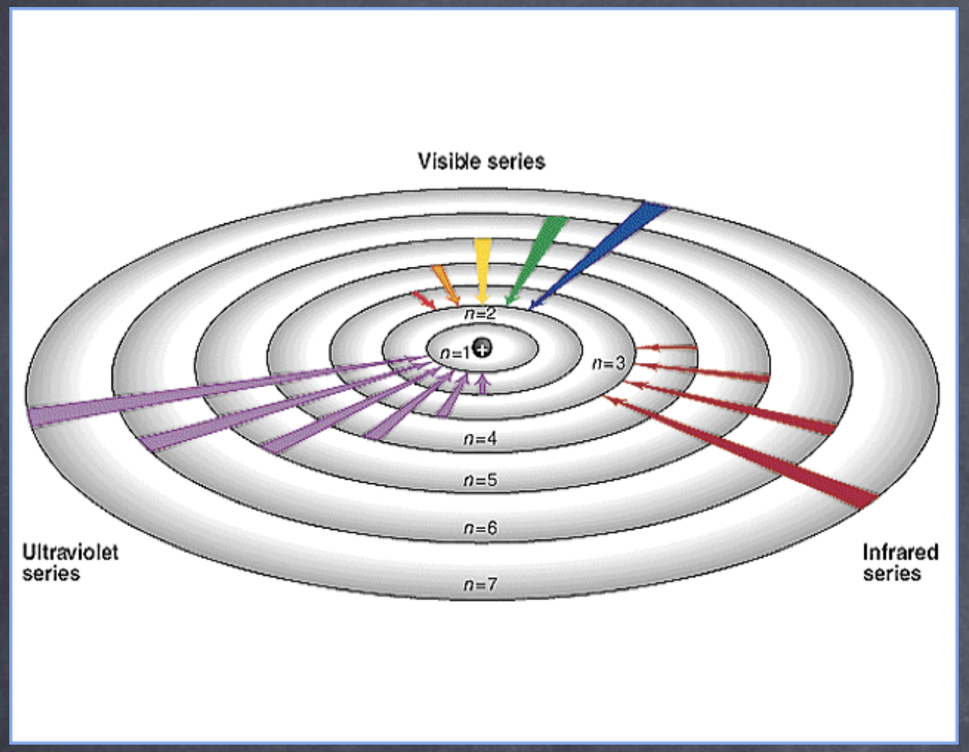
‘Discovery’ of neutron

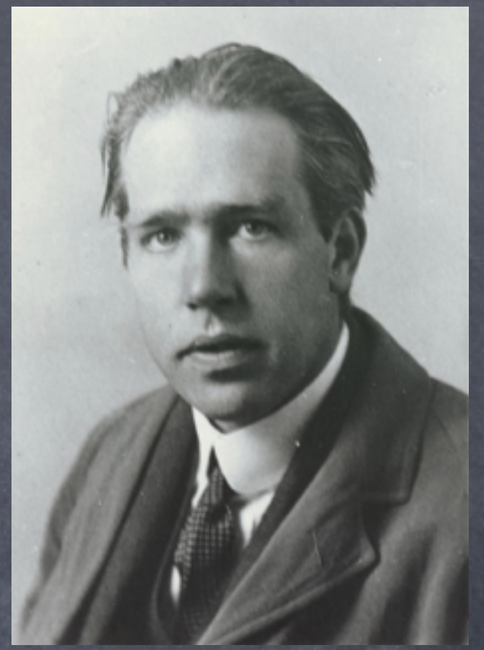


Take home

- Remember Conservation Laws

★How is it known that classical physics cannot explain the properties of the atom?





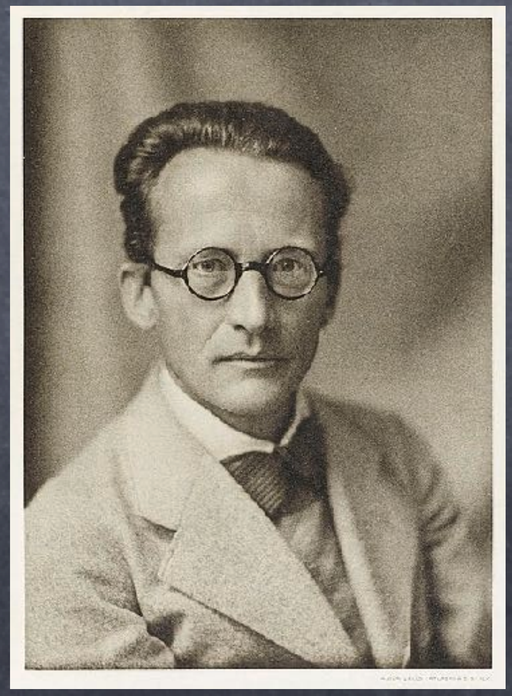
$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^{\,2}} - \frac{1}{n_i^{\,2}}\right)$$

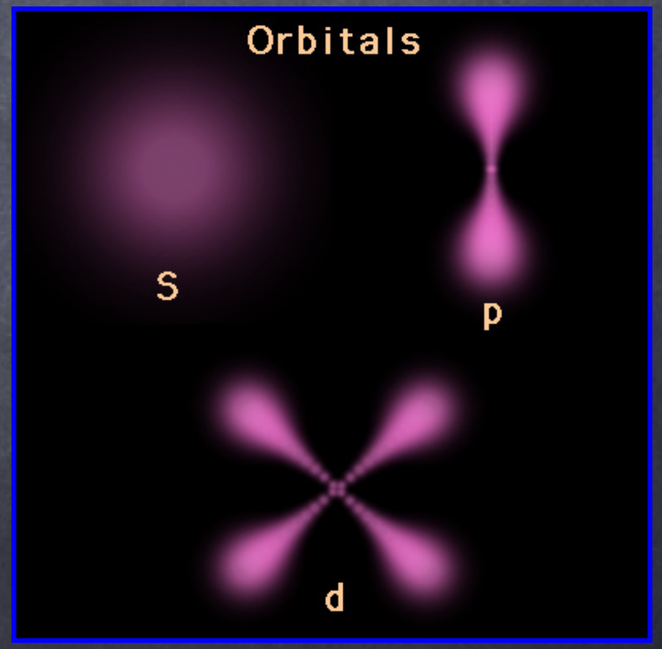
★How is it known that classical physics cannot explain the properties of the atom?

Electrons are standing waves

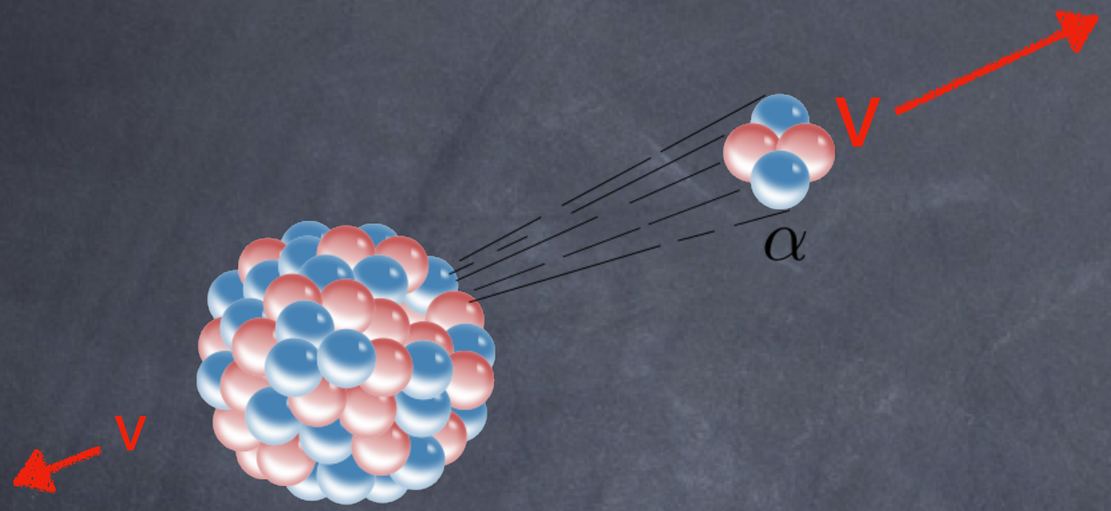
$$p = \frac{h}{\lambda}$$

Electrons are probability clouds

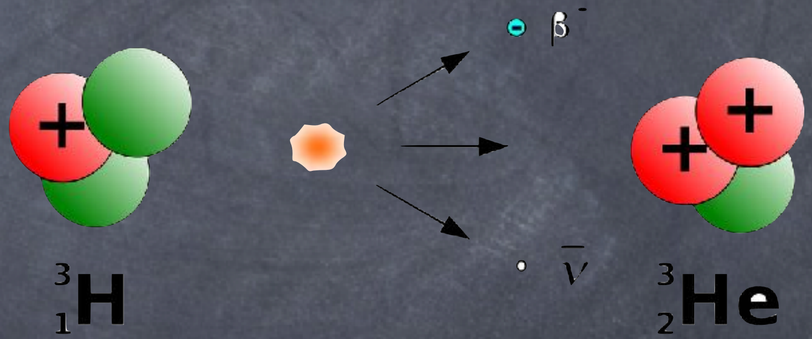




★How can the energy of the atomic nucleus be harnessed?



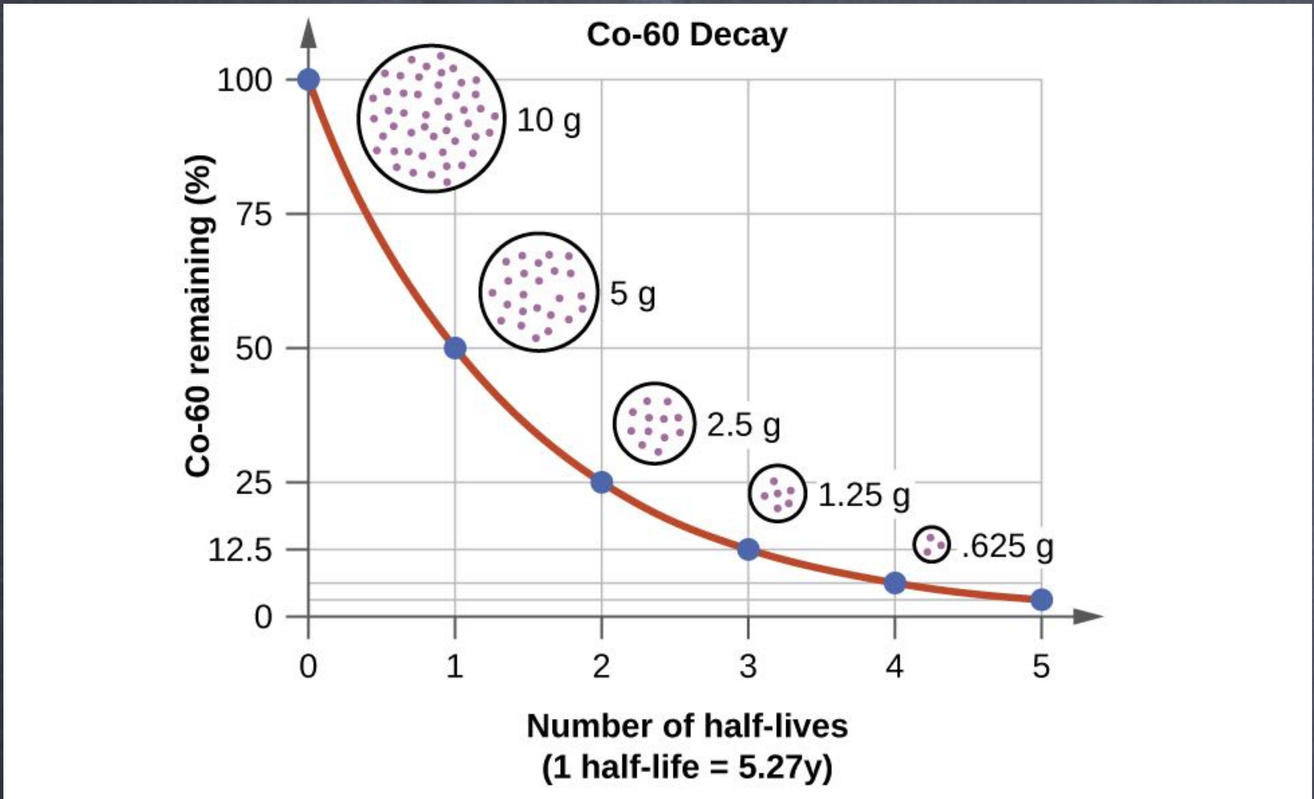
$$^{232}_{90}\mathrm{Th} \longrightarrow {}^{228}_{88}\mathrm{Ra} + {}^{4}_{2}\mathrm{He}$$



Radioactivity

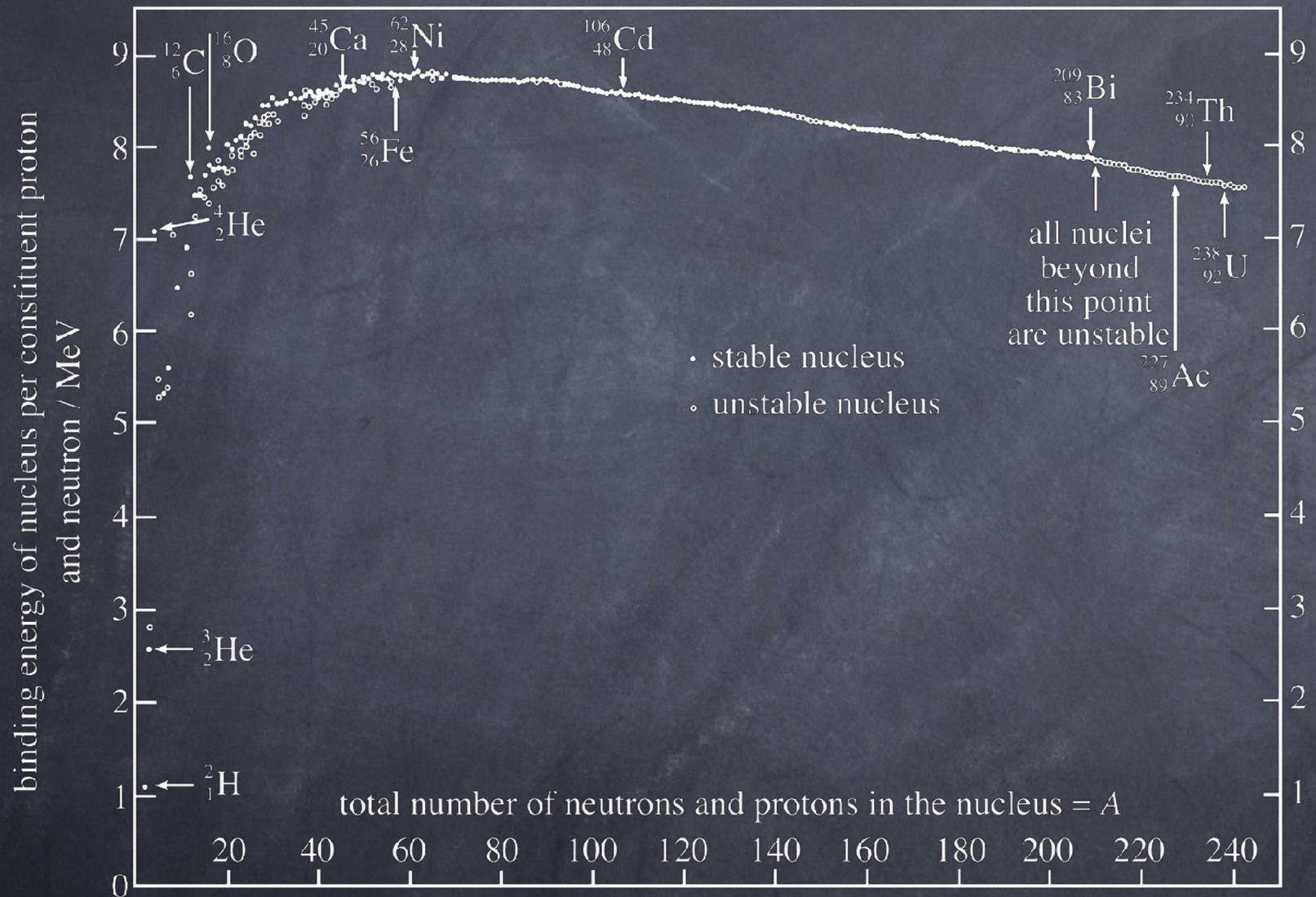
★How can the energy of the atomic nucleus be harnessed?

Half-life



$$N = N_0 e^{-\lambda t}$$

★How can the energy of the atomic nucleus be harnessed?



Fission/fusion/ radioactivity

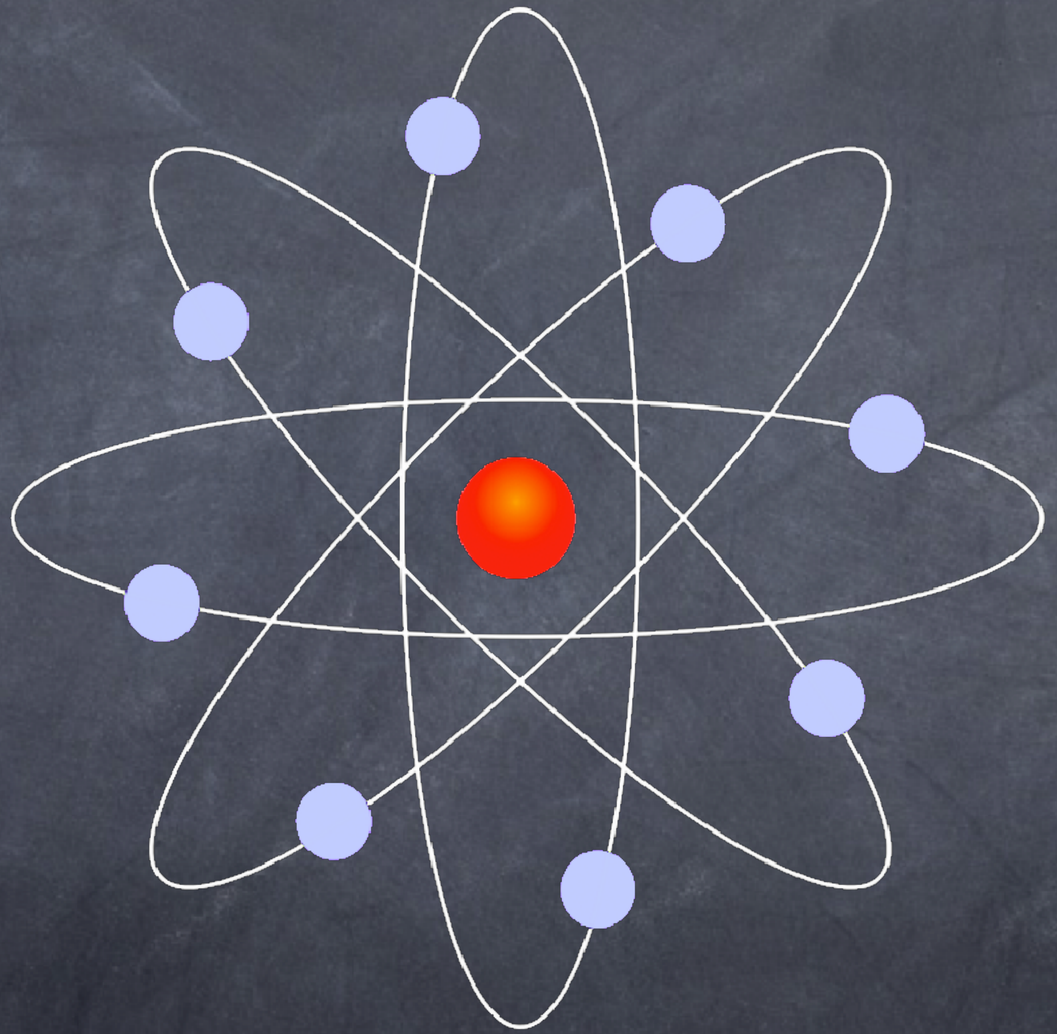
↓

Mass defect

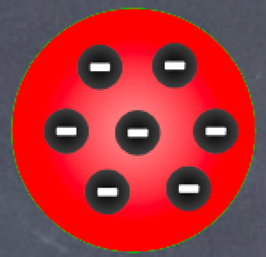
↓ $E=mc^2$

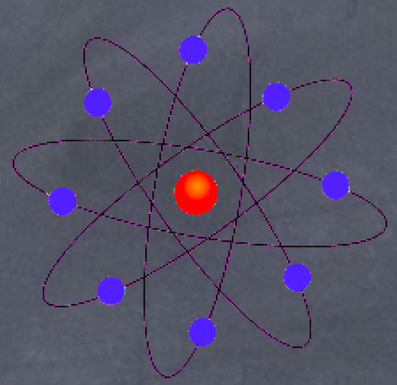
Binding energy per nucleon

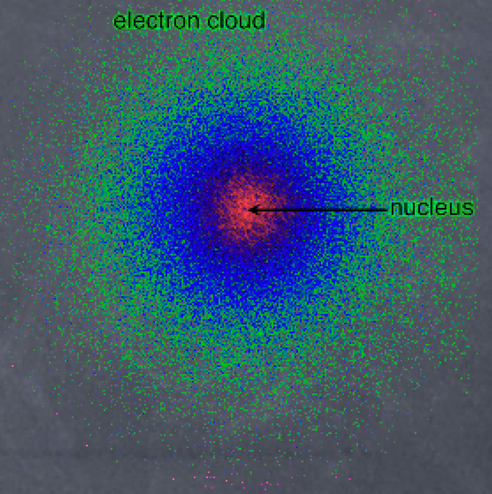
Is this correct?



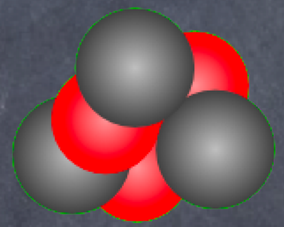
Atom







Nucleus

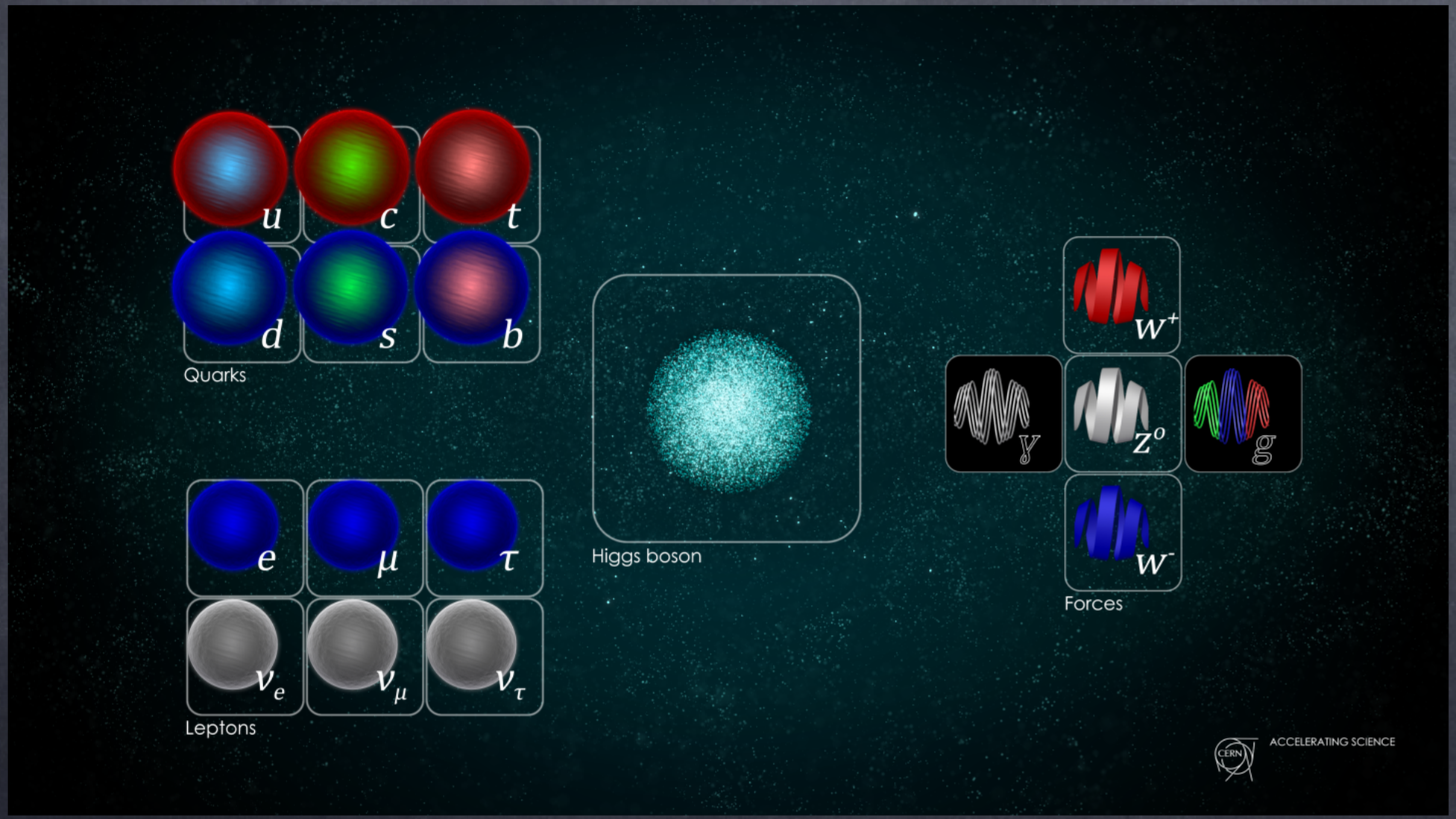


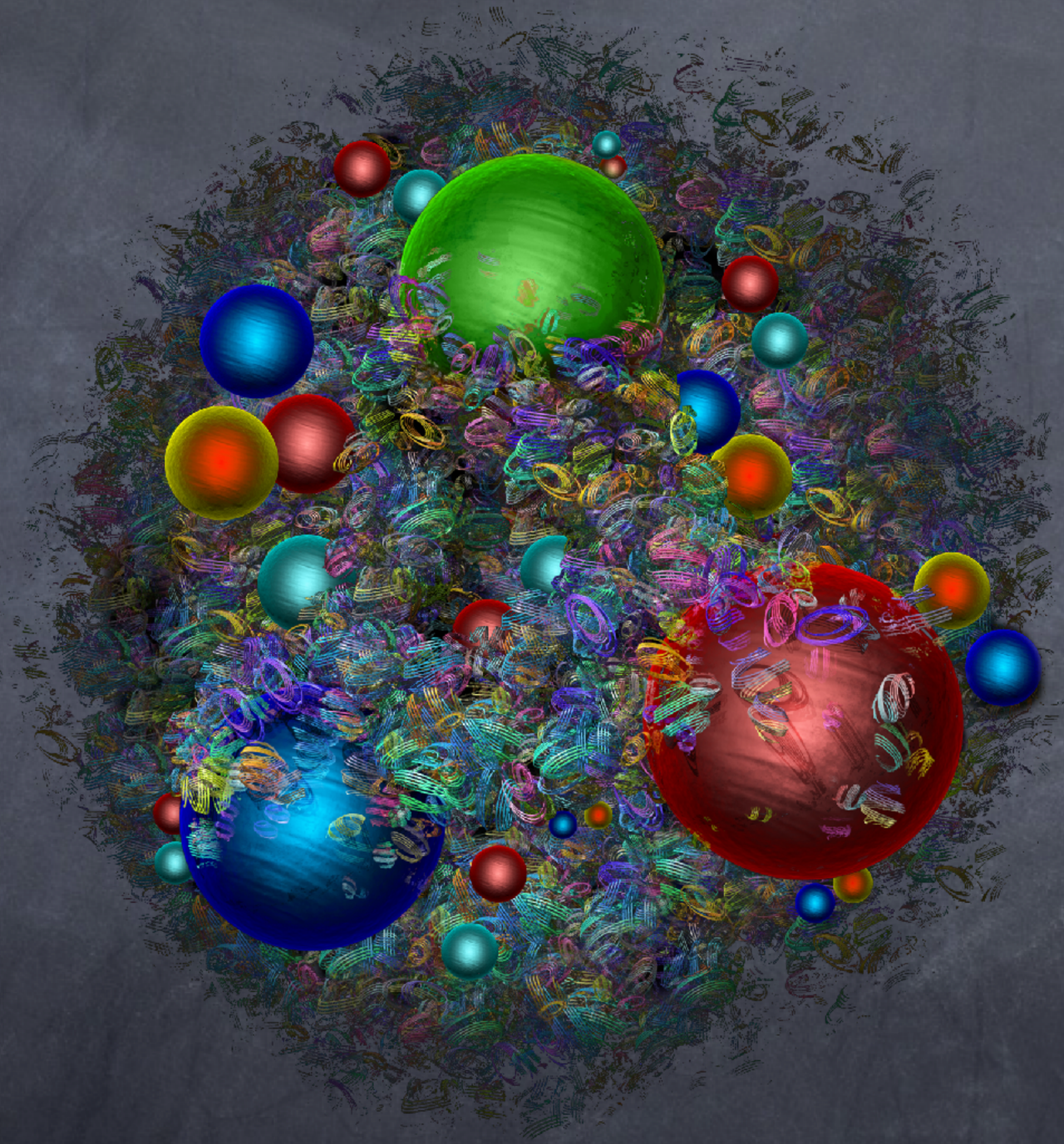
Take home

- how models have been developed (*based on evidence*)
- How models have changed or been modified (*based on evidence*)

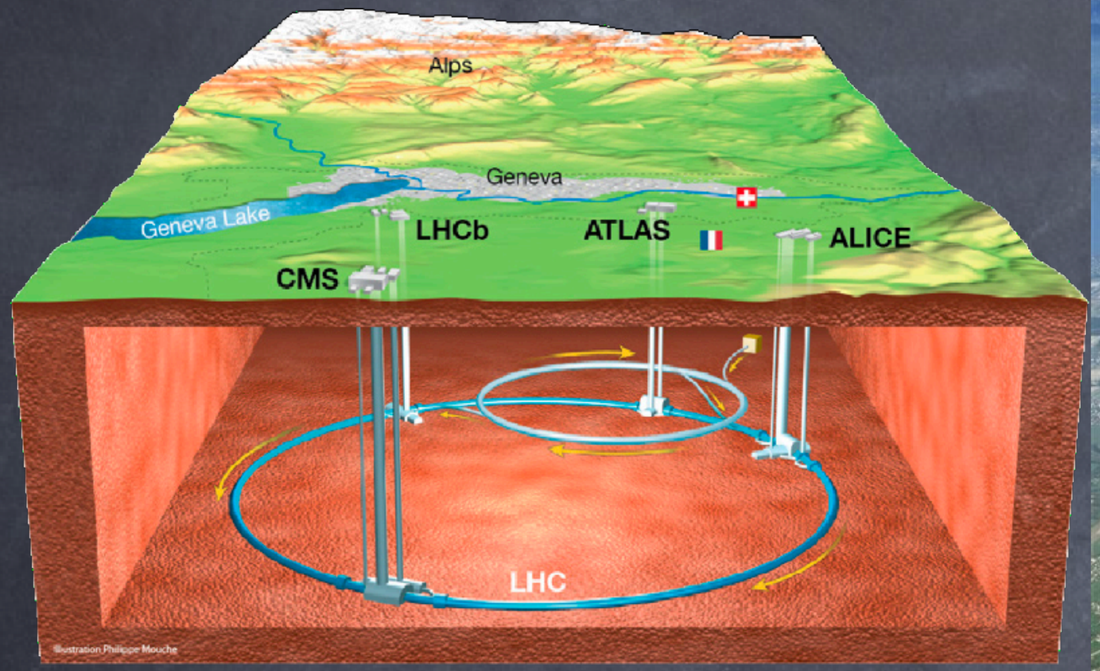
★How can the energy of the atomic nucleus be harnessed?

The Standard Model





★How is it known that human understanding of matter is still incomplete?

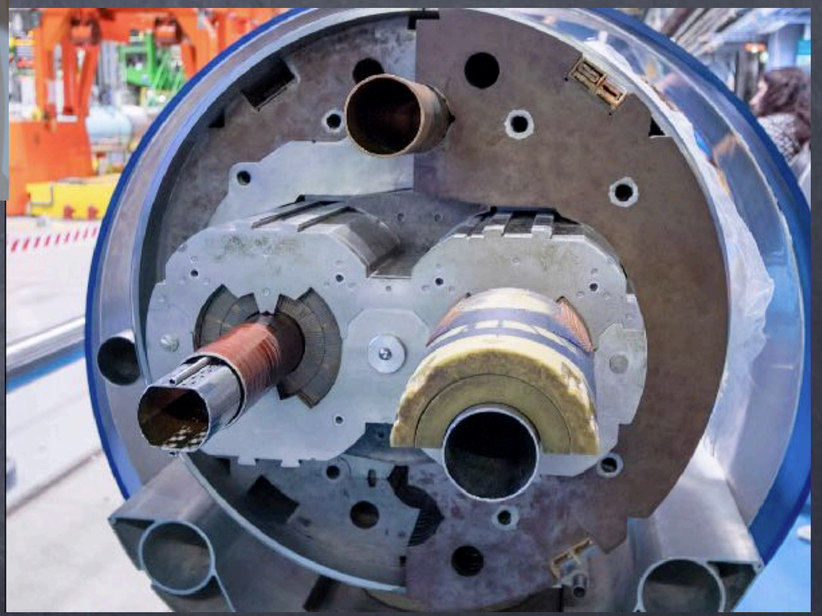


Particle detectors

★How is it known that human understanding of matter is still incomplete?

- ★ M 4
  - ★ Electromagnets
- ★ M 5
  - ★ Circular motion
- ★ M 6
  - ★ Charges in fields
- ★ M 7
  - ★ Relativistic momentum
  - ★ M 8
    - ★ Particle accelerators
    - ★ Standard model

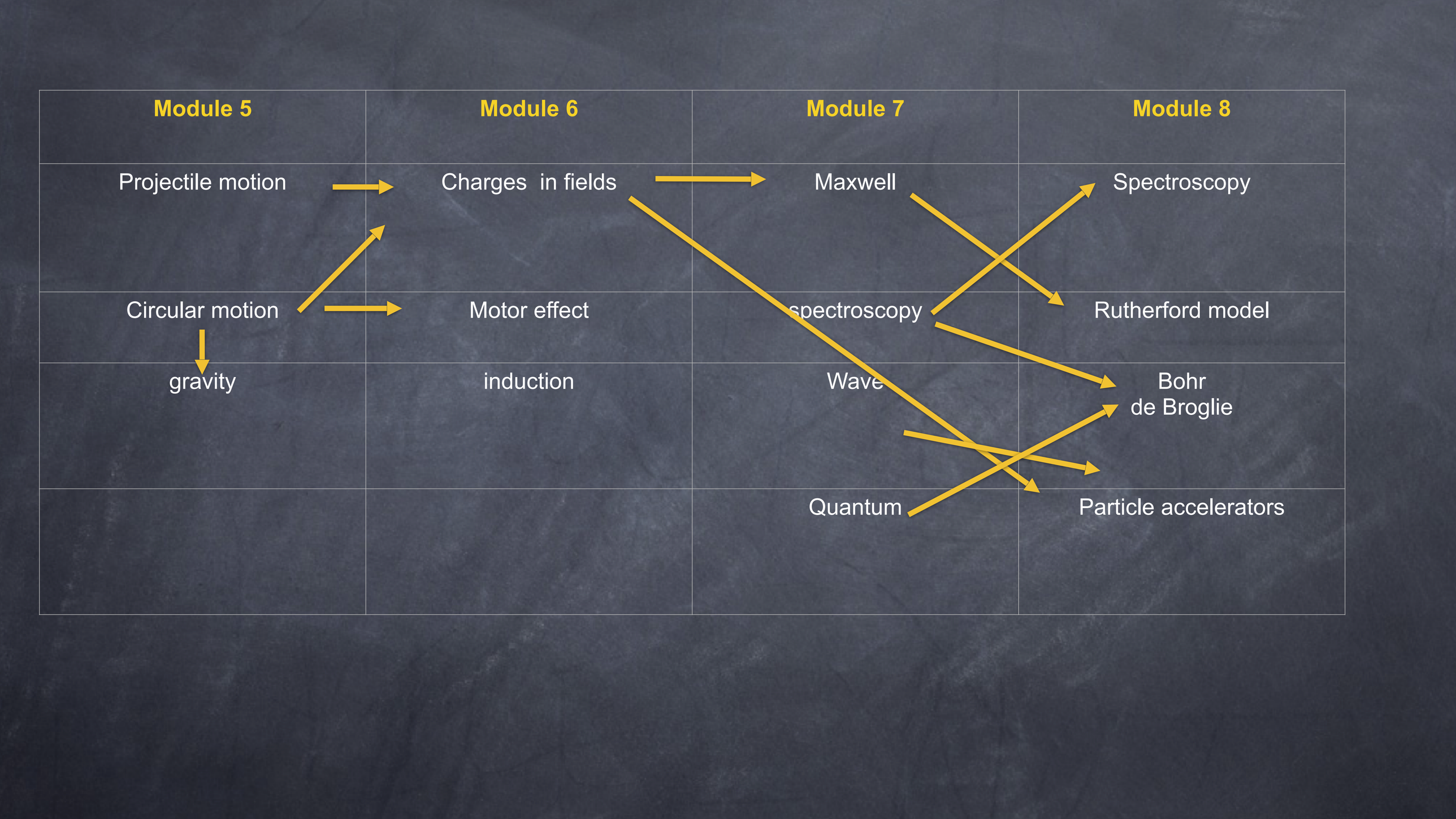
Particle accelerators



Take home

- Understanding particle accelerators reviews many concepts

Module 5	Module 6	Module 7	Module 8
Projectile motion	Charges in fields	Maxwell	Spectroscopy
Circular motion	Motor effect	spectroscopy	Rutherford model
gravity	induction	Wave	Bohr de Broglie
		Quantum	Particle accelerators

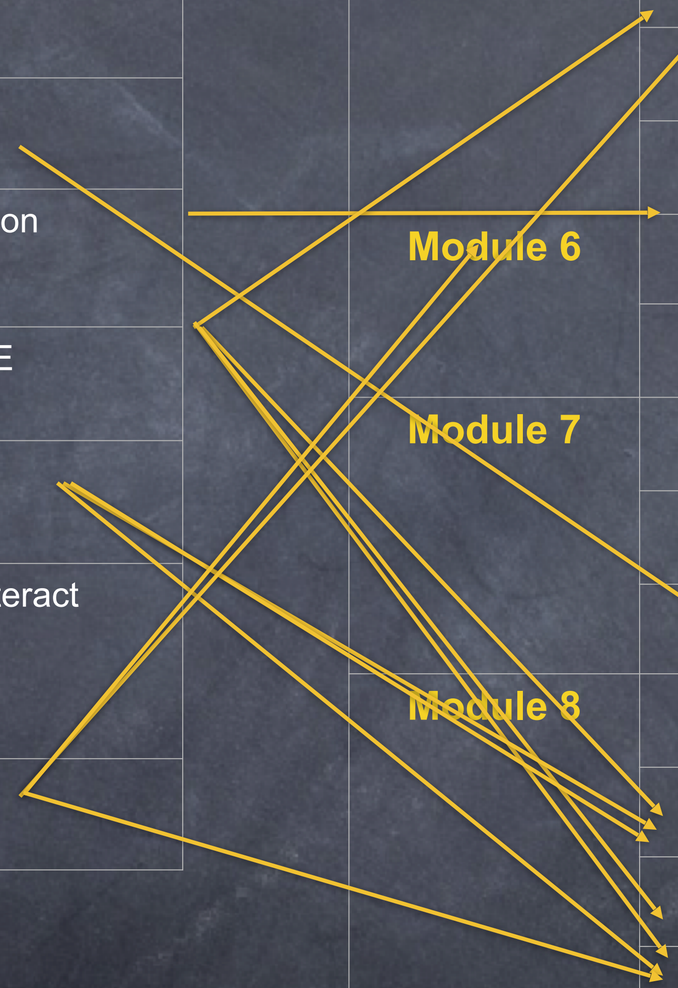


What are the big ticket items?

foundation → **context**

Module 1	vectors
	relativity
Module 2	Causes of motion
	Energy & LCE
	Momentum
Module 3	How do waves interact
Module 4	Fields

Module 5	Projectile motion
	Circular motion
	gravity
Module 6	Charges in fields
	Motor effect
Module 7	Maxwell
	spectroscopy
	SR
Module 8	Spectroscopy
	atomic model
	Nuclear physics
	SM & Particle accelerators



Any questions?

PDF of the slides on my website