2025 HSC Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

Question	Answer
1	B
2	A
3	B
4	D
5	D
6	A
7	B
8	A
9	A
10	C
11	D
12	A
13	C
14	B
15	C
16	A
17	C
18	D
19	B
20	C

Section II

Question 21

Criteria	Marks
• Outlines TWO methods and subsequent observations that could be used to identify each source as either alpha or beta emitters	3
• Outlines a method that could be used to distinguish the sources OR • Identifies TWO methods that could be used to identify each source	2
• Provides some relevant information	1

Sample answer:

Pass the radiation through a thin material to a detector. Observe any changes in counts. The beta source count will be reduced by an amount less than the alpha source count.

Pass each type of radiation through a magnetic field and observe any differences in deflection and observe deflection in opposite directions.

Answers could include:

- Magnetic field
- Electric field
- Cloud chamber

Question 22

Criteria	Marks
• Describes energy transformations in the transformers and in the transmission line	4
• Describes an energy transformation in the transformer or transmission line AND identifies another energy transformation	3
• Describes an energy transformation that occurs OR • Identifies energy transformations	2
• Provides some relevant information	1

Sample answer:

The energy output of both transformer *A* and transformer *B* is less than the energy input. These transformers produce heat energy in their cores due to resistive losses, magnetic effects and mechanical vibrations.

In the transmission line, heat energy is produced due to the resistance of the wires.

Question 23 (a)

Criteria	Marks
• Determines the torque produced on the wire loop by the motor effect	3
• Determines the magnitude of the torque produced OR • Determines the magnitude of the force produced	2
• An appropriate step is performed	1

Sample answer:

$$\begin{aligned} F &= BIL \\ &= 3 \times 10^{-2} \times 2 \times 0.05 \\ &= 0.003 \text{ N} \end{aligned}$$

$$\begin{aligned} \tau &= Fd \\ &= 0.003 \times 0.2 \\ &= 6 \times 10^{-4} \text{ Nm clockwise viewed from the side } B \end{aligned}$$

Question 23 (b)

Criteria	Marks
• States BOTH changes required to produce the results	2
• States ONE change required to produce the result	1

Sample answer:

The magnetic field was quadrupled and the current was halved.

Question 24

Criteria	Marks
• Shows all relevant steps to determine the mass ratio	3
• Makes progress towards determining mass ratio	2
• Provides some relevant information	1

Sample answer:

$$F_C = F_G$$

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

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

$$\frac{1}{2}mv^2 = \frac{GMm}{2r}$$

$$\therefore \quad \frac{GMm_A}{2r_A} = \frac{GMm_B}{2r_B}$$

Or $\dfrac{m_A}{r_A} = \dfrac{m_B}{r_B} \quad \Rightarrow \quad \dfrac{m_A}{m_B} = \dfrac{r_A}{r_B}$

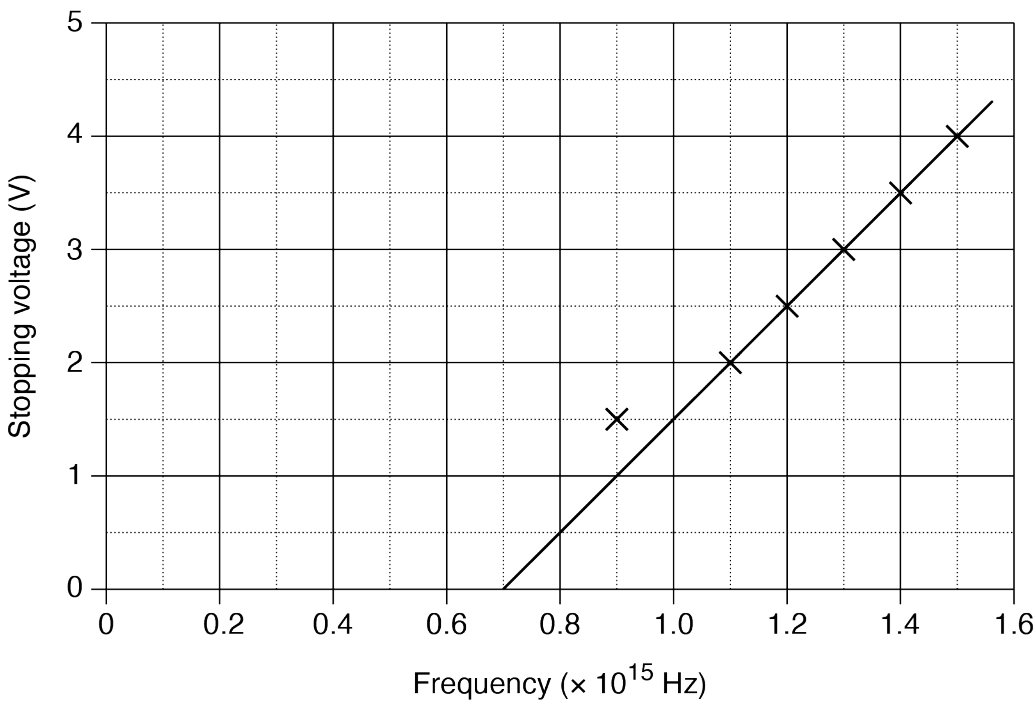
Substitute $r_A = 3r_B$ $\quad \dfrac{3r_B}{r_B} = \dfrac{m_A}{m_B} = 3$

$$\therefore \quad m_A = 3m_B$$

Question 25 (a)

Criteria	Marks
• Correctly plots all data • Draws appropriate line of best fit to determine the threshold frequency	3
• Correctly plots data and determines an x-intercept OR • Correctly plots data and draws an appropriate line of best fit	2
• Correctly plots some data OR • Draws a line of best fit	1

Sample answer:



Threshold frequency of potassium: 0.7×10^{15} Hz or 7×10^{14} Hz

Question 25 (b)

Criteria	Marks
• Shows how the features shown in the experiment are explained by the particle model of light	3
• Relates a feature shown to an aspect of the particle model of light	2
• Provides some relevant information	1

Sample answer:

The photon model of light explains the trend by stating that light consists of discrete packets of energy called photons. The energy of a photon is directly proportional to its frequency ($E = hf$). When photons strike the metal, they transfer energy to electrons. If the photon energy exceeds the work function of the metal, the threshold frequency is exceeded and electrons are ejected with kinetic energy proportional to the excess energy ($KE = hf - \phi$).

As the frequency of light increases, the photon energy increases, resulting in higher kinetic energy for the ejected electrons. This is observed as a higher stopping voltage, which is required to halt the more energetic electrons.

Question 26 (a)

Criteria	Marks
• Calculates the magnitude of the average emf during the rotation	2
• Provides one correct step in the calculation	1

Sample answer:

$\phi = BA$ and $\varepsilon = \dfrac{\Delta\phi}{\Delta t}$

$\therefore\ \varepsilon = \dfrac{\Delta(BA)}{\Delta t} = \dfrac{B\Delta A}{\Delta t}$

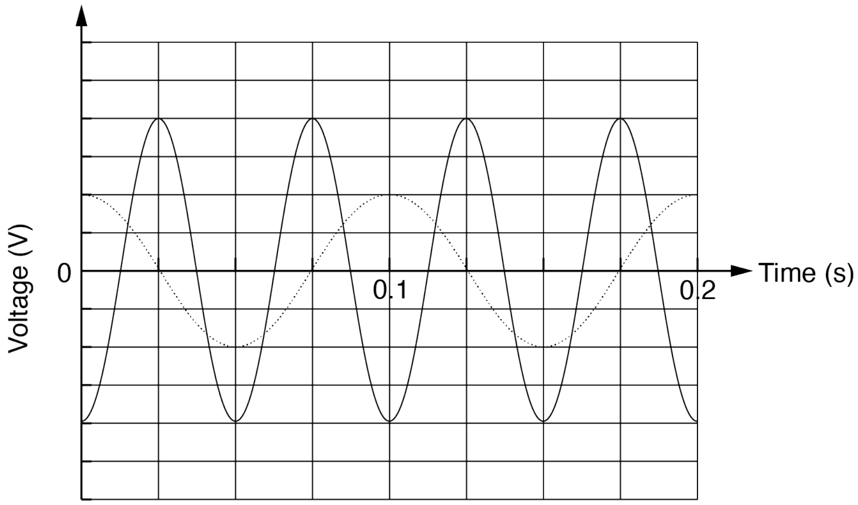
$\varepsilon = \dfrac{0.5 \times 0.4 \times 0.3}{0.1}$

$\varepsilon = 0.6\ \text{V}$

Question 26 (b)

Criteria	Marks
• Sketches an appropriate graph of how the voltage varies with time	3
• Sketches some relevant aspects of the graph	2
• Provides some relevant information	1

Sample answer:



Question 27

Criteria	Marks
• Outlines TWO ways in which Schrödinger's model differs from those of Rutherford and Bohr	3
• Outlines ONE way in which Schrödinger's model differs from those of Rutherford and Bohr OR • Outlines TWO features of Schrödinger's model	2
• Provides some relevant information	1

Sample answer:

In contrast to Bohr's idea of fixed orbits, Schrödinger described orbitals as probabilities of electrons as being in particular locations.

Unlike Rutherford's model in which electrons were imagined as particles orbiting the nucleus, Schrödinger described the electrons as waves, based on the work of de Broglie.

Question 28

Criteria	Marks
• Calculates the minimum speed required for the rider to land on the second ramp	4
• Provides substantial working to calculate the minimum speed	3
• Makes progress towards determining the minimum speed	2
• Provides some relevant information	1

Sample answer:

To calculate u:

In the horizontal direction, $s_x = u_x t$ with $u_x = u\cos(\theta)$, so $t = \dfrac{s_x}{u\cos(\theta)}$

In the vertical direction, $0 = u_y t + \dfrac{1}{2} a_y t^2$ with $u_y = u\sin(\theta)$, so $u = \dfrac{-a_y t}{2\sin(\theta)}$

Substituting into the equation for u gives, $u^2 = \dfrac{-a_y s_x}{2\cos(\theta)\sin(\theta)}$ or $u = \sqrt{\dfrac{-a_y s_x}{2\cos(\theta)\sin(\theta)}}$

For $a_y = -9.8$, $s_x = 16$ and $\theta = 20$

$u = 15.6 \text{ m s}^{-1}$

Question 29 (a)

Criteria	Marks
• Shows steps required to derive the equation	2
• Shows a relevant step	1

Sample answer:

At the top of the circle, $\dfrac{mv^2}{r} = mg$

so, with simplification

$v = \sqrt{rg}$

Question 29 (b)

Criteria	Marks
• Compares the speed of the mass at each point, using the law of conservation of energy • Uses appropriate mathematical relationships	3
• Compares the speed of the mass, using the law of conservation of energy	2
• Provides some relevant information	1

Sample answer:

The speed of the ball at point *A* will be greater than *v* from part (a).

Total mechanical energy = E_k + GPE

At point *B*:

Total mechanical energy $= \frac{1}{2} \times m \times gr + mg(2r)$ = total mechanical energy at *A*

At *A* the gravitational potential energy = mgr and thus $\frac{1}{2} \times m \times gr + 2mgr = mgr + E_{kA}$

Simplifying gives $E_{kA} = 1.5mgr = \frac{1}{2}mv_A^2$

And finally $v_A = \sqrt{3gr} = \sqrt{3}v_B$

Question 30 (a)

Criteria	Marks
• Shows the wavelength is equal to 182 nm	2
• Substitutes one correct value into the appropriate equation	1

Sample answer:

$\lambda = \frac{h}{mv}$ with the mass of an electron 9.109×10^{-31} kg

$$\lambda = \frac{6.626 \times 10^{-34}}{9.109 \times 10^{-31} \times 4 \times 10^{3}}$$

$\lambda = 1.82 \times 10^{-7}$ m

$\lambda = 182$ nm

Question 30 (b)

Criteria	Marks
• Calculates the required distance	2
• Makes one correct substitution into an appropriate formula	1

Sample answer:

Distance between the central bright spot and the centre of the next interference fringe = $\dfrac{\lambda \text{ mL}}{d}$ (m = 1)

$$\text{Distance } = \frac{182 \times 10^{-9} \times 1 \times 0.5}{1 \times 10^{-6}}$$

$$\begin{aligned}\text{Distance } &= 0.091 \text{ m}\\ &= 9.1 \text{ cm}\end{aligned}$$

Question 30 (c)

Criteria	Marks
• Calculates the required potential difference	2
• Makes one correct substitution into an appropriate formula	1

Sample answer:

Using the work-energy relationship, $qV = \dfrac{1}{2} mv^2$

$$V = \frac{mv^2}{2q} = \frac{9.109 \times 10^{-31} \times (4 \times 10^3)^2}{2 \times 1.602 \times 10^{-19}} = 4.5 \times 10^{-5} \text{ V}$$

Question 31

Criteria	Marks
• Provides a comprehensive assessment of the experimental results • Relates the results to both existence and properties of electrons	5
• Provides a sound assessment of the experimental results • Relates the results to the properties and/or existence of electrons	4
• Outlines an experiment and/or results • Relates experimental results to the existence and/or properties of electrons	3
• Outlines a relevant experiment or result OR • Relates an experimental result to the existence or property of electrons	2
• Provides some relevant information	1

Sample answer:

Experimental results and their interpretation have played an essential role in developing and understanding of both the existence and properties of electrons.

It was demonstrated that cathode rays could be deflected by an electric field in a manner consistent with negatively charged particles. This experiment also allowed the deduction that the cathode rays were not electromagnetic waves because the latter would not be deflected by an electric field.

The combined effect of changing the magnitudes of electric and magnetic fields through which the electrons passed was measured and from this the charge-to-mass ratio of the electron was calculated.

Answers could include:

By using electrodes made of different materials, Thomson was able to deduce that the cathode rays' properties were independent of the source of the electrons and hence that they were a constituent of atoms themselves rather than being a product of the cathode ray.

Cathode rays were passed through thin metal foils and the analysis of this behaviour allowed scientists (Lenard/Hertz) to deduce that the electrons had mass.

Crookes' observation that cathode rays travelled in straight lines and cast sharp shadows from which he deduced that the rays were particles and not waves (which would have shown diffraction effects).

Question 32

Criteria	Marks
• Provides a comprehensive analysis of the consequences of special relativity on time, length and motion • Refers to applicable experimental evidence	8
• Provides a thorough analysis of the consequences of special relativity on time, length and motion • Refers to applicable experimental evidence	6–7
• Provides analysis of the consequences of special relativity on time and/or length and/or motion • Refers to some relevant experimental evidence	4–5
• Makes some reference to special relativity and/or related experimental evidence	2–3
• Provides some relevant information	1

Sample answer:

The two postulates of special relativity are: the speed of light in a vacuum is an absolute constant, and all inertial frames of reference are equivalent.

The consequences of these postulates are time dilation, length contraction and relativistic momentum dilation. Time dilation means that the measured time between events increases as the speed of an observer increases. Length contraction means that the length of an object decreases as the speed of an observer increases, and relativistic momentum dilation means that objects (with mass) cannot travel at c as it takes increasing amounts of energy to accelerate objects as they approach the speed of light.

Length contraction and time dilation can both be seen in observations of muons at Earth's surface. The short half-life of muons suggests that there should be very few of them that arrive at Earth's surface from their point of origin high in Earth's atmosphere, but the muon flux is greater than suggested by half-life and distance travelled alone. However, when the distance travelled is considered from the muon's frame of reference, it is length-contracted according to $l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$, giving an effective shorter distance for them to travel. From the perspective of an observer on Earth's surface, the time taken for them to decay is dilated, giving an effective greater amount of time for them to travel before decaying.

The effects of relativistic momentum can be seen in particle accelerators in terms of the increasing amounts of energy to required to accelerate the particles as they approach the speed of light – it is though the objects are much more massive than they are.

Question 33

Criteria	Marks
• Provides a detailed analysis of how experimental evidence and theoretical ideas contributed to the development of the Standard Model of matter	6
• Provides an analysis of how experimental evidence and theoretical ideas contributed to the development of the Standard Model of matter	5
• Describes experiment(s) and idea(s) relating to fundamental particles and/or forces AND links these to the Standard Model of matter	3–4
• Outlines experiments and/or ideas relating to fundamental particles or forces	2
• Provides some relevant information	1

Sample answer:

Experiments and theoretical ideas have both been critical in the development of the Standard Model of matter.

Particle accelerators have been used to verify key ideas about fundamental particles and the structure of matter. Particle accelerators allow for small wavelength ‘matter probes’ at high energies, giving high resolution for probing the structure of matter.

Examples of particle accelerator use in the development of the Standard Model include:
- Verification of the electroweak theory, which says that the electromagnetic and weak nuclear forces are a result of the same interaction.
- The discovery of a Higgs Boson, many decades after it was first proposed as necessary in explaining the mass of particles.
- Verification of the existence of quarks by showing the protons and neutrons have internal structure.

Earlier experiments used simpler equipment such as the cloud chamber which was used to discover antimatter following its earlier theoretical prediction.

Many experiments have verified earlier theoretical ideas, and these confirmations have then in turn allowed the proposal of further ideas, which have in turn later been verified by experiments.

Question 34 (a)

Criteria	Marks
• Calculates the speed using relevant calculations and the provided measurements	2
• Makes a valid step in the calculation	1

Sample answer:

$$d = 2 \times 1.471 \times 10^{11}$$
$$= 2.942 \times 10^{11}\ \text{m}$$

$$v = \frac{d}{t}$$
$$= \frac{2.942 \times 10^{11}}{1 \times 10^{3}}$$
$$= 2.942 \times 10^{8}\ \text{m s}^{-1}$$

Question 34 (b)

Criteria	Marks
• Relates an effect to the calculation of the speed of light	3
• Describes the effect of the ellipticity on the distance OR • Relates a change in distance to the corresponding change in light travel time	2
• Provides some relevant information	1

Sample answer:

If light travels along the long axis of the ellipse, then the distance travelled by the light across Earth's orbit is greater than 2.942×10^{8} m. The effect of this would be to increase the calculated speed of light.

Answers could include:

Reduced speed of light due to measurement of distance along the short axis of the ellipse.

Question 35

Criteria	Marks
• Relates the measurements on the balance to the motion of the magnet and its interactions with the pipe	4
• Relates a measurement on the balance to the motion of the magnet and aspects of its interactions with the pipe	3
• Describes some aspects of the motion of the magnet and relates this to a measurement on the balance OR • Describes the motion of the magnet and/or interactions with the pipe	2
• Provides some relevant information	1

Sample answer:

The reading on the scale has two phases.

1. The magnet accelerates to a maximum speed. This results in an increasing change in magnetic flux causing the creation of an increasing electromagnetic force that opposes the constant gravitational force acting on the magnet. The force on the magnet due to this interaction produces an equal and opposite force on the pipe, which results in an increase in the downward force on the scale.
2. The magnet reaches a constant speed when the upward electromagnetic force is equal and opposite to the weight force of the magnet. The force of the magnet on the pipe will be equal to the weight of the magnet. The reading on the scale will then be the weight of the pipe and magnet, shown in grams.

Question 36

Criteria	Marks
• Comprehensively analyses the motion of both pieces with reference to relevant conservation laws and formulae	8
• Analyses features of the motion of both pieces with reference to relevant conservation laws and formulae	6–7
• Describes a feature of the motion of each piece OR describes features of the motion of one piece • Applies a conservation law and a relevant formula	4–5
• Describes a feature of the motion of a piece • Identifies a relevant conservation law and/or refers to a relevant equation	2–3
• Provides some relevant information	1

Sample answer:

By the law of conservation of momentum, the momentum changes of m_a and m_b resulting from the force produced by the explosion must be equal but opposite.

Since they are of equal mass, the velocity change of both pieces, must be the same, but in opposite directions. Since the velocity of m_a increases by v in the direction in which it was travelling, the velocity of m_b, is also v, but in the opposite direction to which it was travelling.

Hence, relative to the Earth, the velocity of m_b must become zero at that instant.

The orbital velocity of the satellite prior to the explosion is given by

$$v_{\text{orbital}} = \sqrt{\frac{GM}{r}}$$

Hence the instantaneous velocity of m_a as a result of the explosion is double the orbital velocity before the explosion

because $2v = 2\sqrt{\frac{GM}{r}}$ > the escape velocity $v_{\text{esc}} = \sqrt{\frac{2GM}{r}}$ the velocity of m_a after the explosion is greater than the escape velocity.

After the explosion, the pieces m_a will continue travel away from Earth at a decreasing velocity, however because its initial velocity exceeds the escape velocity from the explosion point, it will never stop or return to Earth. Its total energy (kinetic + potential) remains constant and will always be positive.

Consequently, m_b will begin to accelerate, from an initial velocity of zero, towards the centre of Earth. Its acceleration is initially less than 9.8 m s^{-2} because it is not at Earth's surface.

As the force due to gravity on m_b increases, its acceleration increases and so its velocity towards the centre of Earth increases at an increasing rate until it reaches Earth's atmosphere.

Consistent with the law of conservation of energy, until m_b reaches Earth's atmosphere, the sum of its kinetic and potential energy must remain constant and equal to its initial potential energy at the instant after the explosion.

2025 HSC Physics Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 7 Electromagnetic Spectrum	PH12-14
2	1	Mod 6 Electromagnetic Induction	PH12-5, PH12-13
3	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
4	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
5	1	Mod 5 Motion in Gravitational Fields	PH12-12
6	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-4, PH12-13
7	1	Mod 5 Motion in Gravitational Fields	PH12-12
8	1	Mod 5 Projectile Motion	PH12-4, PH12-12
9	1	Mod 7 Electromagnetic Spectrum	PH12-5, PH12-14
10	1	Mod 8 Properties of the Nucleus	PH12-5, PH12-15
11	1	Mod 6 Applications of the Motor Effect	PH12-5, PH12-13
12	1	Mod 7 Light: Wave Model	PH12-5, PH12-14
13	1	Mod 5 Circular Motion	PH12-6, PH12-12
14	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-4, PH12-13
15	1	Mod 8 Origins of the Elements	PH12-5, PH12-15
16	1	Mod 8 Properties of the Nucleus	PH12-5, PH12-15
17	1	Mod 6 Electromagnetic Induction	PH12-6, PH12-13
18	1	Mod 5 Motion in Gravitational Fields	PH12-6, PH12-12
19	1	Mod 7 Light and Special Relativity	PH12-6, PH12-14
20	1	Mod 8 Deep inside the Atom	PH12-15

Section II

Question	Marks	Content	Syllabus outcomes
21	3	Mod 8 Properties of the Nucleus	PH12-6, PH12-15
22	4	Mod 6 Electromagnetic Induction	PH12-7, PH12-13
23 (a)	3	Mod 6 The Motor Effect	PH12-5, PH12-13
23 (b)	2	Mod 6 The Motor Effect	PH12-5, PH12-13
24	3	Mod 5 Motion in Gravitational Fields	PH12-6, PH12-12
25 (a)	3	Mod 7 Light: Quantum Model	PH12-4, PH12-12
25 (b)	3	Mod 7 Light: Quantum Model	PH12-7, PH12-12
26 (a)	2	Mod 6 Electromagnetic Induction	PH12-5, PH12-13
26 (b)	3	Mod 6 Electromagnetic Induction	PH12-4, PH12-13
27	3	Mod 8 Quantum Mechanical Model of the Atom	PH12-15
28	4	Mod 5 Projectile Motion	PH12-6, PH12-12

Question	Marks	Content	Syllabus outcomes
29 (a)	2	Mod 5 Circular Motion	PH12-7, PH12-12
29 (b)	3	Mod 5 Circular Motion	PH12-7, PH12-12
30 (a)	2	Mod 8 Quantum Mechanical Model of the Atom	PH12-7, PH12-15
30 (b)	2	Mod 7 Light: Wave Model	PH12-4, PH12-14
30 (c)	2	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-4, PH12-13
31	5	Mod 8 Structure of the Atom	PH12-7, PH12-15
32	8	Mod 7 Light and Special Relativity	PH12-7, PH12-14
33	6	Mod 8 Deep inside the Atom	PH12-7, PH12-15
34 (a)	2	Mod 7 Electromagnetic Spectrum	PH12-4, PH12-14
34 (b)	3	Mod 7 Electromagnetic Spectrum	PH12-7, PH12-14
35	4	Mod 6 Applications of the Motor Effect	PH12-5, PH12-13
36	8	Mod 5 Motion in Gravitational Fields	PH12-5, PH12-7, PH12-12