Information Bulletin
Archived

Physics 30

Diploma Examinations Program for *Physics 20–30, 2007 Program of Study*

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Others	

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Contents

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Stand-Alone Items with Field Test Data and Commentary

1. Which of the following statements **best** describes an isolated system?

A. No external forces act on an isolated system.

B. Only gravitational forces act on an isolated system.

C. Momentum is always conserved in an isolated system.

D. Kinetic energy is always conserved in an isolated system.

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.765	0.018	0.129	0.088
High:	0.825			
Mid:	0.779			
Low:	0.701			

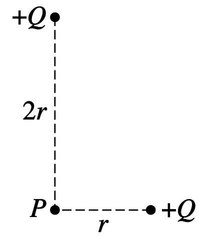
(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group. In this case 76.5% of the total chose A, which is the correct answer. 82.5% of the high group, 77.9% of the middle group, and 70.1% of the low group chose A.)

Commentary

This question assesses the big-picture idea described in 30-A1.3k: it is important to know the characteristics of a system; specifically, to know that if a system is isolated then it is valid to apply conservation of momentum. Students should know that not every system is isolated and know what characteristics must be present in an isolated system; they should then be able to apply that knowledge to support a particular analysis.

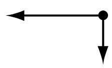
Use the following information to answer the next question.

Two identically charged objects are placed near a point, *P*, as shown below.

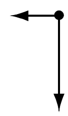


2. Which of the following free-body diagrams, drawn to scale, illustrates the electrostatic forces acting on a positive test charge placed at point *P*?

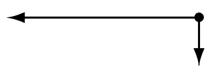
A.



B.



C.



D.

Statistical performance:

Group	A	B	C	D
Total:	0.336	0.194	0.401	0.069
High:			0.571	
Mid:			0.338	
Low:			0.325	

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

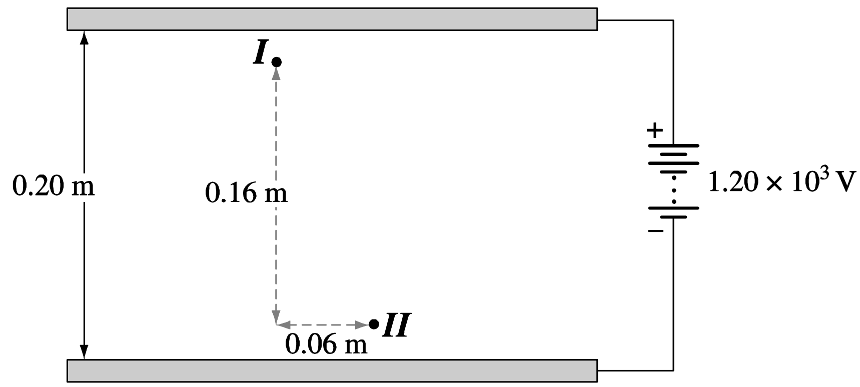
Commentary

This question combines the mandated expectations of 30-B1.7k and 30B1.3s in which "*Students will* determine, quantitatively, the magnitude and direction of the electric force on a point charge due to two or more other point charges in a plane; analyze data and apply mathematical and conceptual models to develop and assess possible solutions…• use free-body diagrams to describe the electrostatic forces acting on a charge."

In this question students needed to determine the directions of the two forces and then apply the $\frac{1}{r^2}$ nature of the Coulomb force to estimate the relative lengths of the force vectors.

Use the following information to answer the next question.

Two oppositely charged parallel plates are separated by 0.20 m and have an electric potential difference of 1.20×10^3 V across them. Locations *I* and *II* are in the region between the plates, as shown below.



3. How much work is required to move an electron from location *I* to location *II*?

A. 5.8×10^{-17} J

B. 1.5×10^{-16} J

C. 1.6×10^{-16} J

D. 1.9×10^{-16} J

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.044	0.270	0.258	0.407
High:		0.405		
Mid:		0.221		
Low:		0.220		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

This question explores outcome 30-B2.9k, in which "Students will explain, quantitatively, electrical interactions using the law of conservation of energy," combined with 30-B2.4k, in which "*Students will* define electric potential difference as a change in electric potential energy per unit of charge" and 30-B2.5k, "*Students will* calculate the electric potential difference between two points in a uniform electric field."

The most telling comment from a student who wrote the field test is "does the pathway taken make a difference?" Clearly, this student, and the more than 70% of the students who got this question wrong, did not bring the necessary learning from Physics 20: work is done when the force and the displacement are parallel. The most commonly selected answer, D, assumes that work done horizontally adds to the work done vertically. Choice C uses the work done along the imaginary hypotenuse. Students are able to use formulas mandated by the word “calculate,” but the program also mandates an informed use of equations through the use of the word “explain.”

4. *As an electron accelerates in an electric field and moves farther from the negatively charged plate, its kinetic energy* ___***i***___ *, because its electric potential energy* ___***ii***___ *, because of the work done by the electric* ___***iii***___ *.*

The statement above is completed by the information in row

Row	***i***	***ii***	***iii***
A.	increases	decreases	field
B.	increases	decreases	force
C.	decreases	increases	field
D.	decreases	increases	force

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.393	0.268	0.224	0.110
High:		0.368		
Mid:		0.256		
Low:		0.176		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary
This question requires students to apply the content mandated in 30-B2.9k, in which “*Students will* explain, quantitatively, electrical interactions using the law of conservation of energy”; 30B-2.3s, in which “*Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions”; and 30-B2.2k, in which “*Students will* compare forces and fields.”

The General Outcome B2 is “*Students will* describe electrical phenomena, using the electric field theory.”

Students should understand that one model used to explain forces is field theory. The exchange of virtual photons and string theory are two other models that physicists are currently using.

5. *The path of a charged particle travelling perpendicularly through a uniform magnetic field is deflected due to* ___***i***___ *and the speed of the charged particle will* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
A.	an unbalanced magnetic force	stay the same
B.	an unbalanced magnetic force	increase
C.	a balanced centripetal force	stay the same
D.	a balanced centripetal force	increase

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.246	0.305	0.290	0.158
High:	0.389			
Mid:	0.186			
Low:	0.154			

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

This question requires students to bring the skill mandated in 30-B3.3s, in which "*Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions…• analyze, quantitatively, the motion of an electric charge following a straight or curved path in a uniform magnetic field, using Newton's second law and vector addition."

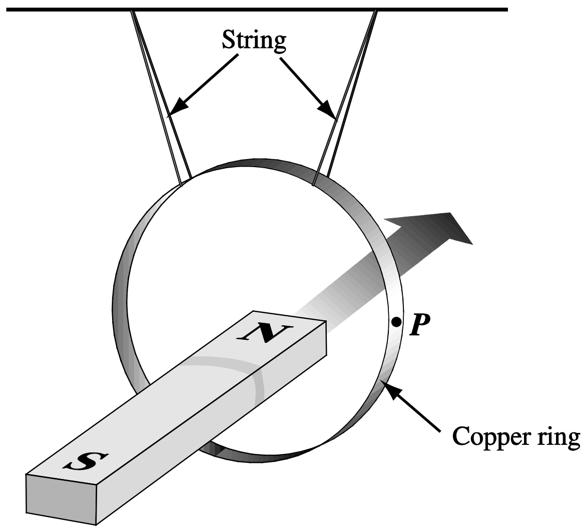
This outcome illustrates how the *Physics 20-30 Program of Studies, 2007,* is a complete program of study – students need to bring from Physics 20 a solid foundation in Newton's laws, a firm grasp of free-body diagrams, and some vector-analysis skills.

This question was designed to explore a widely held misconception: if the speed remains constant, then the forces must be balanced. The clinging to this misconception can be addressed partially through very careful word usage and beginning the analysis of almost every situation with an FBD.

This leads to another interesting observation based on student performance: Students know how to use vector components and are quite calculator-competent in doing so, but haven't any idea why the components must be perpendicular. For example, although in Physics 20 students learn that a force does work only in the direction of the force and that they need to find the parallel component, the students do not apply that learning later in Physics 20 or to circular motion.

Use the following information to answer the next question.

A copper ring is suspended by insulating string. The north pole of a bar magnet is brought toward the ring.



The approaching magnet induces an electron flow in the copper ring. The interaction of the magnetic effects of the induced electron flow and the bar magnet causes the ring to swing.

6. *The ring swings* ___*i*___ *the magnet and the electron flow at point P is toward the* ___*ii*___ *of the page.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	away from	top
B.	away from	bottom
C.	toward	top
D.	toward	bottom

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.345	0.245	0.254	0.145
High:		0.387		
Mid:		0.231		
Low:		0.112		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

This question addresses outcome 30-B3.9k: "*Students will* describe, qualitatively, the effects of moving a conductor in an external magnetic field, in terms of moving charges in a magnetic field." In other words, students will be able to describe the generator effect. The equations are absent from the equation sheet because the program outcome is qualitative, but the topic is still mandated. This question also requires students to apply a hand rule. There are lots of processes students can use to determine how to apply the hand rule: conservation of energy (in other words, Lenz's Law) or an application of a single charge moving because of a magnetic field and relative motion. Lenz's Law is a quick way to explain magnetic interactions that is based on conservation of energy. The new program is designed along threads, one of which is conservation of energy. It is expected that top-end students are able to use the threads to build solutions in unusual contexts.

Another interesting aspect to this question is the sentence, "The interaction of the magnetic effects of the induced electron flow and the bar magnet causes the ring to swing." One of the teacher comments from the validation suggested that we replace "magnetic effects" with "magnetic fields". There is a physics problem with that wording – fields don't exist. Physicists use the concept of field to explain forces and forces at a distance, but a field is just a model. Although many teachers know this, we are still graduating students who have a deep misunderstanding of action-at-a-distance, along with little awareness of the evolution of models and how this evolution has affected descriptions of the real world.

Use the following information to answer the next question.

A group of students conducts a series of tests to determine which combination of optical media results in the largest critical angle for one wavelength of visible light. The table below lists the index of refraction for each of the media used.

Medium Used	**Index of Refraction for this Wavelength of Visible Light**
Water	1.33
Glass	1.46
Quartz	1.54
Flint Glass	1.70

7. The largest critical angle for this wavelength of visible light will be produced for the path from

A. glass to quartz

B. quartz to glass

C. water to flint glass

D. flint glass to water

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.091	0.197	0.336	0.368
High:		0.321		
Mid:		0.177		
Low:		0.092		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

This question is designed to explore 30-C1.6k, in which "*Students will* describe, quantitatively, the phenomena of reflection and refraction, including total internal reflection."

The student performance on this question shows that both C and D drew more students than the correct answer, B. Although students could find the answer to this question using trial and error and repeated calculations, an understanding of critical angle and the ratio of the optical indices of the two media is a better approach. In particular, a large critical angle means that light bends very little moving from one medium to the next so the smallest ratio would be best, with the light ending in the less optically dense medium.

8. An object is placed 35.0 cm from a diverging lens that has a focal length of 20.0 cm. The image produced is

A. real and larger than the object

B. real and smaller than the object

C. virtual and larger than the object

D. virtual and smaller than the object

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.274	0.214	0.231	0.279
High:				0.462
Mid:				0.231
Low:				0.153

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

The program of studies mandates that students analyze simple optical systems. On the diploma, we will be using the terms *converging* and *diverging* rather than convex and concave. Classifying a lens by the effect that it has on light rays will allow the students to interact confidently with a wide selection of lens types: for example, a converging lens may be double convex, planoconvex, or meniscoid in shape.

The depth of coverage of lenses and mirrors is such that students should be calculator-competent; students must be able to apply a sign convention to a given situation and interpret the significance of the sign of the answer. Although the program mandates ray diagrams, their role is to support the mathematical analysis.

9. A particular atom emits a photon of wavelength 471 nm when one of its electrons undergoes a transition from one stable energy level to another. If the final energy level has an energy of –6.04 eV, then the energy of the initial level is

A. –2.64 eV

B. –3.40 eV

C. –6.04 eV

D. –8.68 eV

Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.210	0.440	0.069	0.278
High:		0.622		
Mid:		0.385		
Low:		0.329		

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Commentary

This question explores the scope of the new program and is helpful is establishing how this program is different from the *Physics 20-30 Program of Studies, 1995* version. This outcome is 30-D2.5k, in which "*Students will* calculate the energy difference between states, using the law of conservation of energy and the observed characteristics of an observed photon." The new program mandates a deep understanding of conservation principles applied in a range of circumstances. The old program mandated the use of many different formulas to describe special cases: for example, the Balmer equations for the emission lines of hydrogen or the Bohr equations for radius and energy.

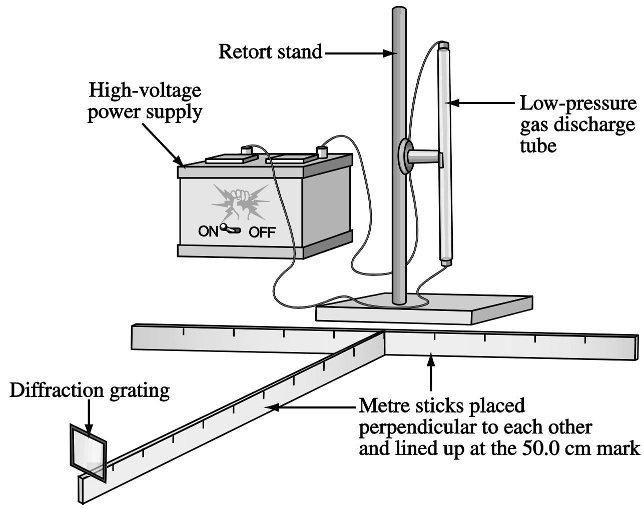
Items in Scenario with Field Test Data and Commentary

Use the following information to answer the next three questions.

A group of students is given a low-pressure helium gas-discharge tube, a high-voltage power supply with wire leads, a retort stand with clamps for holding the discharge tube, a diffraction grating, and two metre sticks.

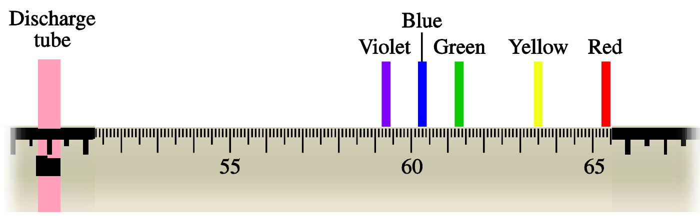
The group clamps the gas-discharge tube into a vertical position and connects it to the power supply. A metre stick is placed horizontally, directly in front of the discharge tube so that the tube is lined up with the 50.0 cm mark. The second metre stick is placed perpendicular to the first metre stick, directly in line with the center of the discharge tube. Finally, a diffraction grating is placed 100 cm from the low-pressure helium gas-discharge tube. The diagram below illustrates the set-up.

Perspective View of Student Apparatus



When the power supply is switched on, an electric current passes through the gas, and the tube emits a pinkish-yellow light.

Using a diffraction grating etched with lines that are spaced 4.35×10^{-6} m apart, the students observe a series of brightly coloured spectral lines to the right of the location of the discharge tube, as shown below.



The yellow spectral line is significantly brighter than the other lines.

10. *If the students replace the diffraction grating with one that has more lines per millimetre etched onto it, then the red spectral line will be observed* ___***i***___ *the discharge tube. In order to keep the red spectral line in approximately the same position as in the original observations, the students would have to move the diffraction grating* ___***ii***___ *the discharge tube.*

The statements above are completed by the information in row

Row	***i***	***ii***
A.	closer to	closer to
B.	closer to	farther from
C.	farther from	closer to
D.	farther from	farther from

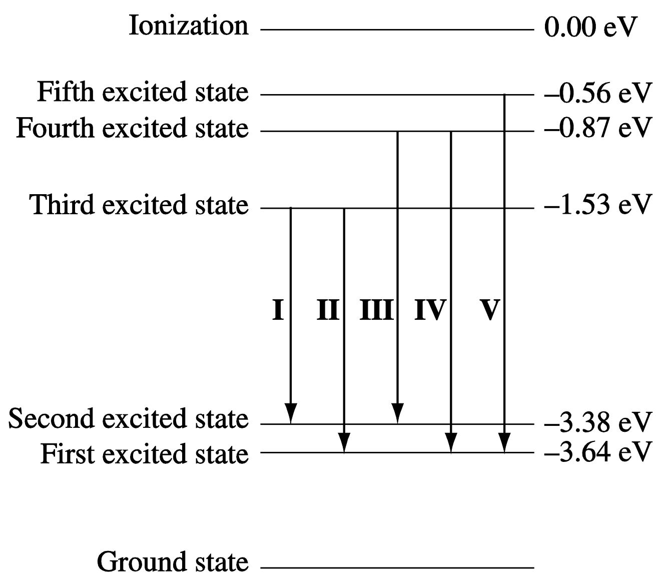
Numerical Response

1. The wavelength of the yellow spectral line for helium, based on the students' observations, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ m. The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

(Record the **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following additional information to answer the next question.

The students are also given the following reference energy level diagram for helium. Transitions I, II, III, IV, and V correspond to the spectral lines that were observed by the students.



11. Which of the following rows matches the transition corresponding to the violet spectral line, and the frequency of a photon corresponding to the violet spectral line?

Row	**Transition corresponding to the violet spectral line**	**Frequency of a photon corresponding to the violet spectral line**
A.	I	7.44×10^{14} Hz
B.	I	4.47×10^{14} Hz
C.	V	7.44×10^{14} Hz
D.	V	4.47×10^{14} Hz

Multiple-choice 10 Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.085	0.371	0.413	0.127
High:			0.546	
Mid:			0.330	
Low:			0.363	

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Numerical-response 1 Statistical performance:

Group	**Correct**	**Incorrect**	**No Response**
Total:	0.138	0.827	0.035
High:	0.299	0.649	0.052
Mid:	0.066	0.915	0.019
Low:	0.038	0.925	0.038

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Multiple-choice 11 Statistical performance:

Group	**A**	**B**	**C**	**D**
Total:	0.159	0.170	0.502	0.152
High:			0.639	
Mid:			0.509	
Low:			0.325	

(The values represent the proportion that made that selection. The *high* and *low* groups each contain approximately 25% of the group.)

Selected NR responses and their frequency:

	Response	Frequency (%)	Plausible reasoning leading to that answer.
		3.53	No response.
	2186	5.30	Uses the location of the central maximum (0.50 m) and n = 1.
	2764	3.53	Uses 63.5 cm as x and n = 1. How can visible light have a wavelength on the order of 10^{-4} m? Also, it is an invalid application of the $\lambda = \frac{xd}{nl}$ formula if the angle is greater than 10°.
	2766	5.30	Uses the value of 63.5 as x and n = 1 but doesn't address SI prefix conversion correctly. How can visible light be on the order of 10^{-6} m?
	4356	4.24	This is the value of "*d*" given in the information box.
Y	5827	0.35	Correct answer using the always valid $\lambda = \frac{d \sin \theta}{n}$.
	5875	3.18	Uses the value of (63.5–50) cm as x and n = 1. How can visible light have a wavelength on the order of 10^{-5} m?
	5876	0.71	Uses the value of (63.5–50) cm as x and n = 1 but doesn't address SI prefix conversion correctly. How can visible light have a wavelength on the order of 10^{-6} m?
Y	5877	13.43	Uses the correct value for x, converted to metres and n = 1, in the special case $\lambda = \frac{xd}{nl}$.

Commentary
The investigation described here is an excellent way for students to hit several program of studies mandated outcomes: They get to observe the spectrum using the principle of diffraction (30-C1.2s), they get to make measurements (30-C1.2s) and analyze those measurements (30-C1.3s and 30-D2.5k), and they get to apply process and knowledge from one part of the program (General Outcome C1) to another (General Outcome D2).

The performance of the students on these questions seems to imply that they are not familiar with the mandated tasks.

Multiple-choice question 10 explores the mandated activity in 30-C1.3s: "*Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions...• demonstrate the relationship among wavelength, slit separation and screen distance, using empirical data and algorithms." Only half of the top-performing students were able to answer this question correctly.

Numerical-response question 1 mimics an actual laboratory experience: students need to read the value of the centre of the yellow maximum, subtract the 50 cm from the centring of the metre stick, convert to units of m, and then recognize that the full spectrum was the first order spectrum so that $n = 1$. In the classroom, students who have done labs like this should have seen the first order spectra appear on the metre stick to the left and right of the central maximum and even the second order spectra appear near the far ends of the metre stick.

In 30-C1.10k, the program mandates that students will solve problems using two formulas: $\lambda = \frac{xd}{nl}$ and $\lambda = \frac{d \sin\theta}{n}$. Many students apply the first formula in every situation. This is unfortunate because it is a special-case equation, like $E_{\mathrm{k}} = \frac{1}{2}mv^2$. For the light equation, it is valid only when x is small compared to l or, in other words, when θ is less than 10°. In this question, the angle to the yellow light is around 7.7° and the two formulas disagree on the third digit.

Multiple-choice question 11 takes the students from the observations to an atomic-model representation of what is occurring inside the atom. This moves the students into section 30-D2.5k and 30-D2.1s.

There are many ways in which classroom teachers can expand on this set of questions to promote learning in their classrooms:

1. Have the students complete this activity in the real world. (30-C1.2s)
2. Have the students design and perform a different lab after doing this one to determine the slit separation. (30-C1.1s)
3. Have the students explore the different spectra produced by different elements. (30-D2.2s)
4. Have the students compare the spectra produced using a diffraction grating to one using a prism. (Remember that comparing involves both similarities and differences.) (30-C1.2k, 30-C1.2s)
5. Have the students compare an "apparent" spectrum, like the one described here, with a "real" spectrum that has been projected onto a screen.
6. Use the spectra of various gases to identify what is present in a "mystery" sample. (30-D2.1sts)

The Numerical-Response Scenario on Physics 30 Diploma Examinations

When the Physics 30 Diploma Examination changed to a machine-scored only format, the assessment of big-picture understanding mandated by the program moved from the analytic question to a two-question numerical-response scenario.

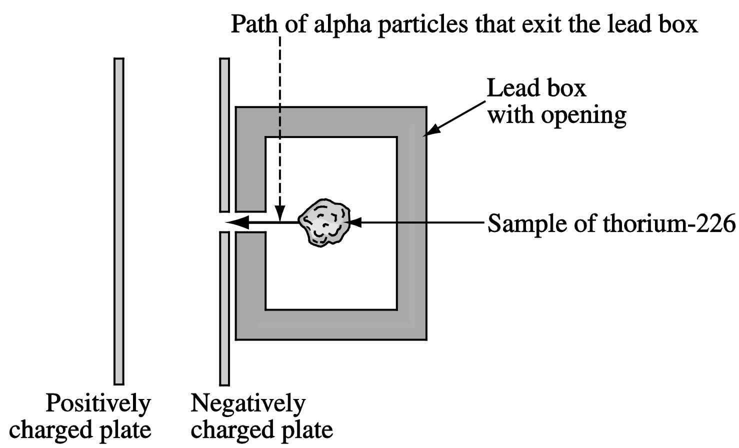
The first question will ask the students to provide a calculated answer. The second question will ask them to identify the physics principles that they are using **in the order** that the principles are used.

Consider the analytic question that was released in the *2009-2010 Physics 30 Information Bulletin*:

Use the following information to answer this analytic question.

A sample of thorium-226 is stored in a lead box, as shown below. Thorium-226 undergoes alpha decay. The lead box has a small opening on the left side to allow a stream of alpha particles to escape.

Top-Down View of Apparatus



In the sample, a nucleus of thorium-226 is at rest when it undergoes alpha decay. The daughter nucleus produced, radium-222, has a mass of 3.67×10^{-25} kg and moves to the right at 3.10×10^{5} m/s immediately after the decay. The thorium-226 nucleus, the radium-222 nucleus, and the alpha particle form an isolated system.

To the left of the lead box are two parallel plates, one positively charged and the other negatively charged, that together produce a uniform electric field. The parallel plates are 2.00 cm apart. The escaping alpha particles are stopped by the electric force just before they reach the positively charged plate. The complete apparatus is in a vacuum.

Written Response—10 marks

3. **Determine** the magnitude of the electric force acting on an alpha particle.

Marks will be awarded based on the relationships among the two physics principles* that you state, the formulas that you state, the substitutions that you show, and your final answer.

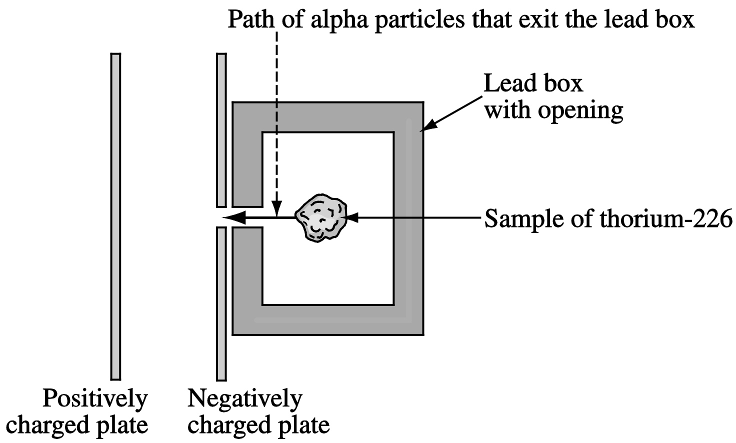
*** The physics principles are given on the tear-out data sheet included with this examination.**

On the examination, this question would appear as follows.

Use the following information to answer the next two questions.

A sample of thorium-226 is stored in a lead box, as shown below. Thorium-226 undergoes alpha decay. The lead box has a small opening on the left side to allow a stream of alpha particles to escape.

Top-Down View of Apparatus



In the sample, a nucleus of thorium-226 is at rest when it undergoes alpha decay. The daughter nucleus produced, radium-222, has a mass of 3.67×10^{-25} kg and moves to the right at 3.10×10^{5} m/s immediately after the decay. The thorium-226 nucleus, the radium-222 nucleus, and the alpha particle form an isolated system.

To the left of the lead box are two parallel plates, one positively charged and the other negatively charged, that together produce a uniform electric field. The parallel plates are 2.00 cm apart. The escaping alpha particles are stopped by the electric force just before they reach the positively charged plate. The complete apparatus is in a vacuum.

Numerical Response

2. The magnitude of the electric force acting on the alpha particle, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ N. The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

(Record the **four digits** of your answer in the numerical-response section on the answer sheet.)

Key answers: 4911

Numerical Response

3. Two of the physics principles numbered on the data sheet must be used to determine the magnitude of the electric force acting on the alpha particle. The two principles, in the order in which they must be used, are

Number:	____________	and	____________
Physics Principle:	**Used First**		**Used Second**

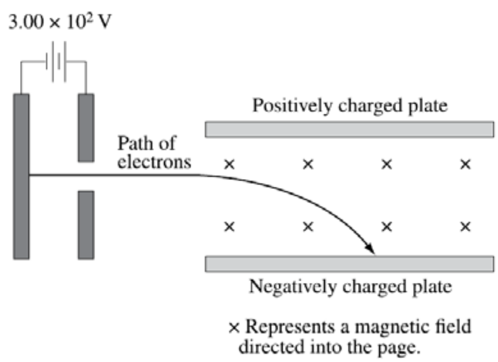
(Record all **two digits** of your answer in the numerical-response section on the answer sheet.)

Key answers: 41, 43, or 45

Second example of the numerical-response scenario. These questions are based on a question that was released on the *September 2009 Formative Assessment Materials* document.

Use the following information to answer the next two questions.

Electrons are accelerated from rest by an electric potential difference of 3.0×10^2 V. These electrons enter a region that contains mutually perpendicular electric and magnetic fields. The electric field has a magnitude of 8.5×10^5 N/C and the magnetic field has a magnitude of 2.0×10^{-1} T.



Numerical Response

4. The magnitude of the instantaneous acceleration experienced by an electron as it first enters the region containing the perpendicular fields, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{\boldsymbol{cd}}$ m/s^2. The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Key answers: 2117

Numerical Response

5. Two of the physics principles numbered on the data sheet must be used to determine the magnitude of the instantaneous acceleration experienced by an electron as it first enters the region containing the perpendicular fields. The two principles, in the order in which they must be used, are

Number: __________ and __________
Physics Principle: **Used First** **Used Second**

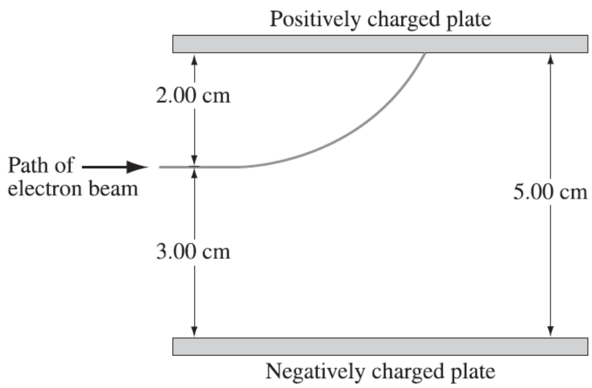
(Record the **two digits** of your answer in the numerical-response section on the answer sheet.)

Key answers: 31 or 51

Third example of the numerical-response scenario. These questions are based on the analytic question that was on the *January 2009 Physics 30 Diploma Examination*.

Use the following information to answer the next two questions.

Two horizontal plates are separated by a distance of 5.00 cm. A beam of electrons is directed, horizontally, into the region between the plates. The path of the beam is deflected as shown below. Electrons in the beam have a speed of 9.00×10^6 m/s as they enter the region between the parallel plates. The electric field strength in the region between the plates is 3.10×10^3 N/C.



Note: This diagram is **not** drawn to scale.

Numerical Response

6. The horizontal distance travelled by an electron in the beam in the region between the horizontal plates, expressed in units of centimeters, is __________ cm.

(Record your **three-digit** answer in the numerical-response section on the answer sheet.)

Key answers: 7.71

Numerical Response

7. Two of the physics principles numbered on the data sheet must be used to determine the horizontal distance travelled by an electron in the beam in the region between the horizontal plates. The two principles, in the order in which they must be used, are

Number: ___________ and ___________
Physics Principle: **Used First** **Used Second**

(Record the **two digits** of your answer in the numerical-response section on the answer sheet.)

Key answers: 10

Assessing Skills on Physics 30 Diploma Examinations

When the Physics 30 Diploma Examination changed to a machine-scored only format, the assessment of two-dimensional vector analysis and graphing skills needed to change, too. In general, these questions will be part of a context-based scenario of items. The examples given here reflect only the new style of question. Lists following the examples illustrate what the rest of the context or additional classroom activities might look like.

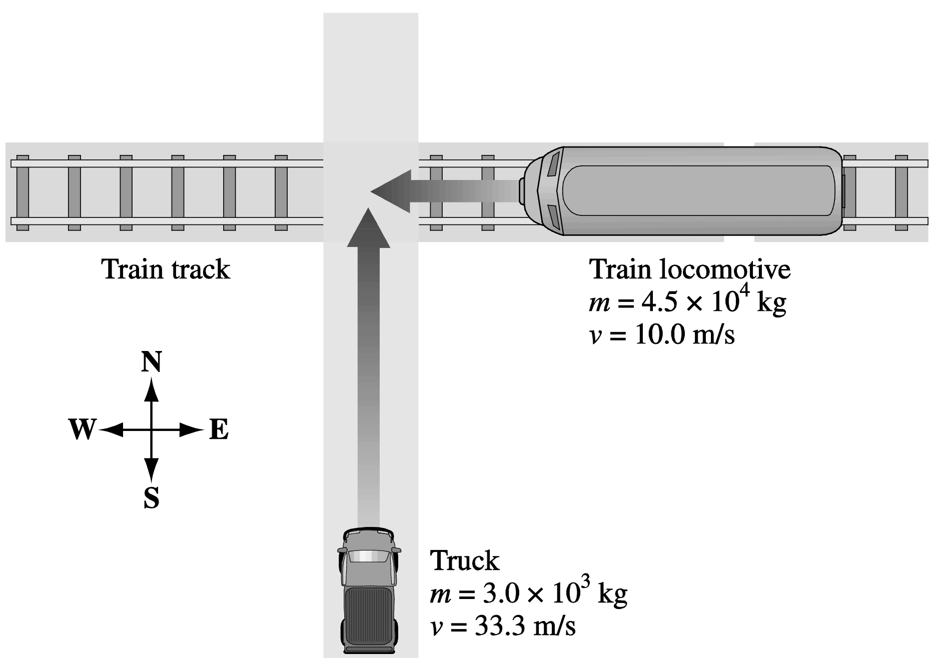
Two-Dimensional Vector Skills

Because two-dimensional vector analysis is a calculator-based competency, many students are fairly successful. The top-performing students are able to answer multiple-choice items correctly, even when the linear analysis is the foundation for one or more of the alternatives. The middle- and bottom-performing students are strongly attracted to the linear answers. None of the answers for multiple-choice items test whether the students' calculators are in radian mode. The questions on the diploma will be designed so that calculators in radian mode will provide nonsensical values which should act as a warning flag to the students.

The new question style looks something like this:

Use the following information to answer the next question.

In a movie stunt, a car and a train locomotive intentionally crash. The collision is illustrated in the diagram below.



Numerical Response

8. The magnitude of the momentum of the truck-train system immediately before the collision, expressed in scientific notation, is ***a.b*** $\times 10^{c}$ kg·m/s. You will need to record the values of ***a*** and ***b***.

The direction of the momentum of the truck -train system immediately before the collision is ***ef*** degrees, north of west. You will need to record the values of ***e*** and ***f***.

The values of ***a***, ***b***, ***e***, and ***f*** are _____, _____, _____, and _____.
a ***b*** ***e*** ***f***

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 4613

Additional questions may include

1. Identify whether conservation of momentum is valid in the car-train system. Explain how the presence or absence of friction affects the classification of the system. (30-A1.3k)
2. Which of the vehicles will experience the greater force? the greater impulse? the greater acceleration? (30-A1.2k, 30-A1.3s)
3. Classify the collision as being elastic or inelastic. Justify your classification. (30-A1.5k)

Graphing Skills

The graphing-skill assessment has required more creative question types so that we can confidently assess student graphing skills. The plotted data will be provided, the students will need to draw a line of best fit and then analyze it. The plotted data is provided so that similar interpretation skills are required of students using a straight edge to sketch the line and students using linear regression on their graphing calculators.

At marking, we have observed that students will produce poor lines of best fit by connecting either the first and last data points or by connecting the origin to the last data point. The plotted data on the diploma examination will have enough scatter that the two practices described above will produce poor lines of best fit and the answers generated by the students will fall outside the allowed range. Other practices seen at marking, such as single data point ratios for the slope, or calculating a slope using adjacent data points should, as a rule, also generate answers that fall outside the allowed range. Students in Physics 30 are expected to have valid graphical analysis skills.

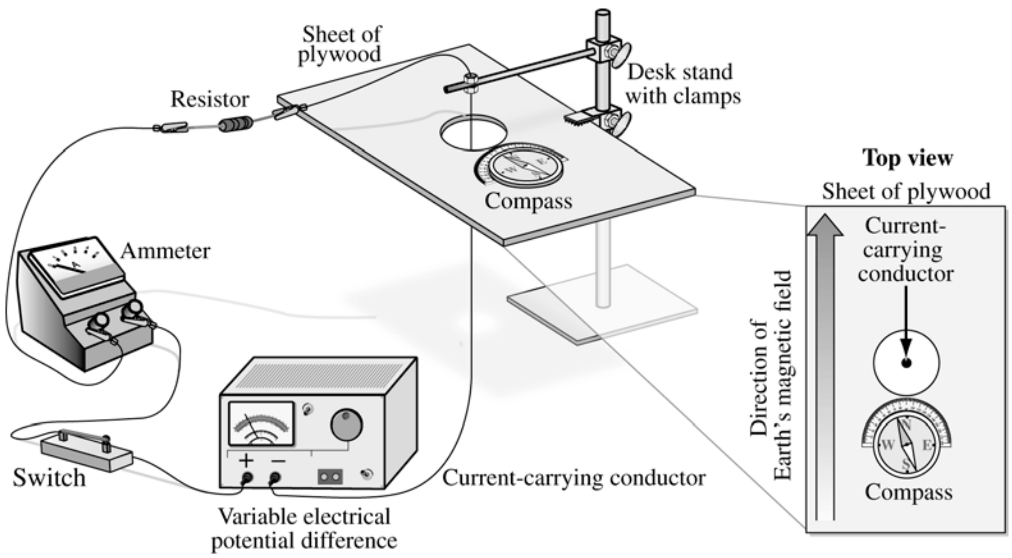
In mathematics, a straight line is defined by the slope of the line and a point on the line. To be able to be sure that students have provided a line of best fit, one question will require the students to provide information reflecting those two parts of the line. This must be a single question because otherwise a student could miss two marks for one error, contrary to assessment practice in the Assessment Sector.

To keep the question from being only a mathematics question, the analysis will be of either the slope or a point, often an intercept, in terms of the physics significance in the context provided. The other piece of information will need to be provided, but **not** used in the analysis.

First example of a graphing-skills question. This question is based on the graphing question from the *Physics 30 2009–2010 Information Bulletin*.

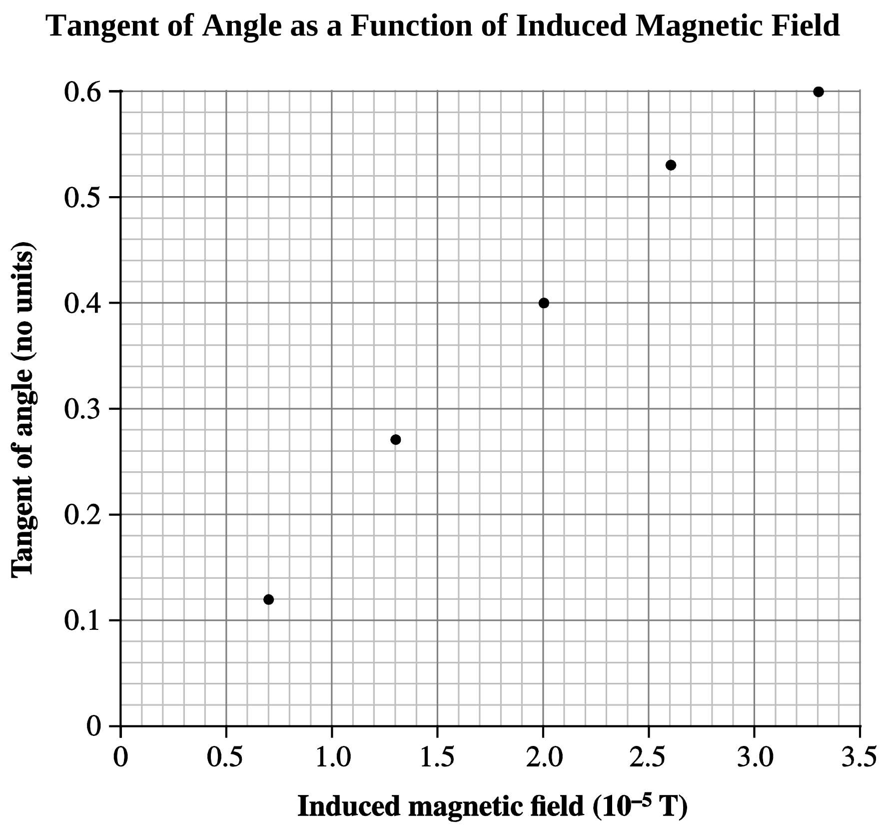
Use the following information to answer the next question.

A group of students conducts an investigation to determine the horizontal component of Earth's magnetic field, B_{Earth}. Their apparatus is shown below.



The compass is placed on the plywood so that the compass needle points toward the conductor and toward the north, N, symbol on the compass. The switch is closed, and the variable electrical potential difference source is set to a non-zero voltage. The current is measured using the ammeter, and the angle of deflection of the compass needle is measured using a protractor. Several trials are conducted with increased voltages.

The students' data are plotted below.



Numerical Response

9. The *y*-intercept of the line of best fit, expressed in scientific notation, is $\boldsymbol{a} \times 10^{-\boldsymbol{b}}$ (no units). You will need to record the values of ***a*** and ***b***.

Using the slope, the experimental value of the magnitude of B_{Earth}, expressed in scientific notation, is $\boldsymbol{e.f} \times 10^{-\boldsymbol{g}}$ T. You will need to record the values of ***e*** and ***f***.

The values of ***a***, ***b***, ***e***, and ***f*** are _____, _____, _____, and _____.
a ***b*** ***e*** ***f***

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Allowed Answers: 1253, 1254, 2253, 2254

Using linear regression, the line of best fit has a *y*-intercept of 1.3×10^{-2} (no units) and a slope of $1.87 \times 10^{4}\ \text{T}^{-1}$, which gives an experimental value for B_{Earth} of 5.30×10^{-5} T.

A hand-drawn line of best fit has a *y*-intercept of 0.02 (no units) and a slope of $1.84 \times 10^{4}\ \text{T}^{-1}$, which gives an experimental value for B_{Earth} of 5.40×10^{-5} T.

Disallowed Answers: 3249, 0056, 0055 (invalid graphing practices)

A first-to-last line has a *y*-intercept of –0.03, an *x*-intercept of 0.2, and a slope of $2.06 \times 10^{4}\ \text{T}^{-1}$, which gives a B_{Earth} value of 4.9. This answer would be recorded as 3249.

An origin-to-last line has a *y*-intercept of 0 and a slope of $1.84 \times 10^{4}\ \text{T}^{-1}$, which gives a B_{Earth} value of 5.60×10^{-5} T or 5.50×10^{-5} T. This answer would be recorded as 0056 or 0055.

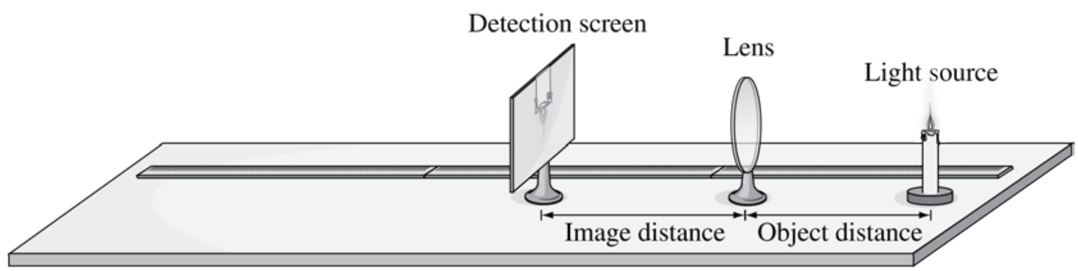
Additional questions and activities may include

1. Sketch the shape and direction of the magnetic field induced by the current in the wire. Explain how you used a hand rule to determine your answer. (30-B3.2s, 30-B3.4k)
2. Draw the vector addition diagram and show how the tangent of the angle is used to determine the magnitude of B_{Earth}. (30-B3.3s)
3. Explain (not identify) the cause of the *y*-intercept. (30-B3.3s)
4. Design a different procedure that would produce measurements that could be used to determine the magnitude of B_{Earth}. (30-B3.1s)
5. Compare the strength of earth’s magnetic field to that of a permanent magnet or an electromagnet. (ST4)
6. Compare gravitational, electric and magnetic fields in terms of their sources, shapes and directions. (Remember, comparing involves both similarities and differences.) (30-B3.2k)

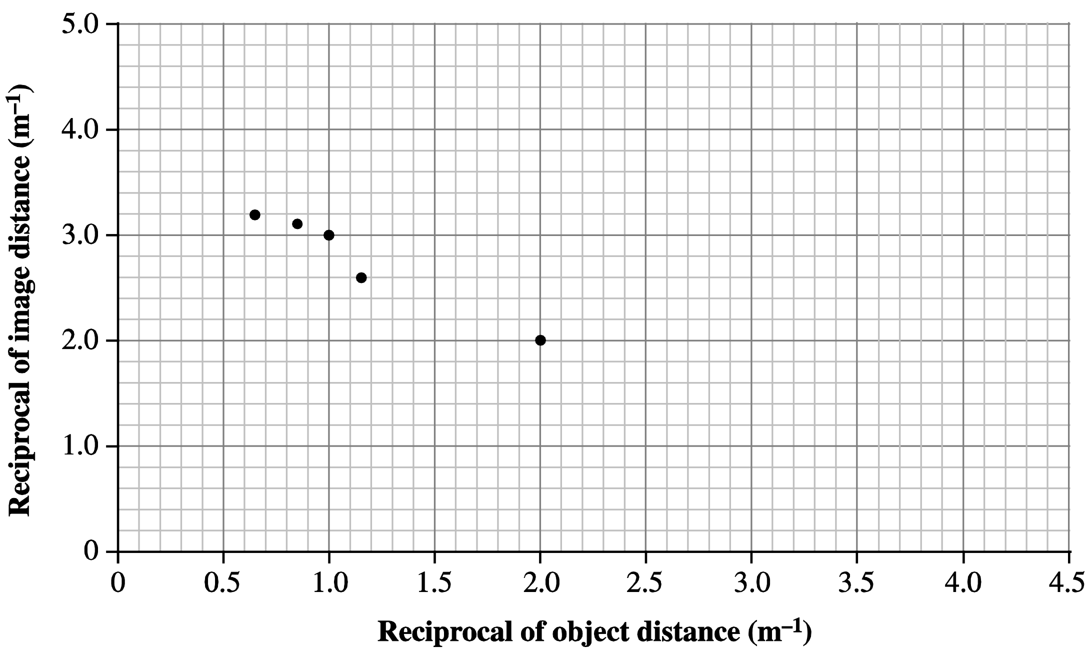
Second example of a graphing skills question. This question is based on the *Physics 30 January 2009 Diploma Examination*.

Use the following information to answer the next question.

Some physics students do an experiment to find the focal length of a converging lens. They set up an optical bench and measure the image distance as a function of the object distance.



Their data are plotted blow.



Numerical Response

10. The slope of the line is ***–a.b***. You will need to record the values of ***a*** and ***b***.

Using the *y*-intercept, the experimental value of the focal length of the lens, expressed in units of centimetres, is ***ef*** cm. You will need to record the values of ***e*** and ***f***.

The values of ***a***, ***b***, ***e***, and ***f*** are _____, _____, _____, and _____.
a ***b*** ***e*** ***f***

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answers: 0926, 0925, 1026, 1025

Disallowed answers: 8627, 8726, 8626, 8727

Additional questions or activities

1. Use a ray diagram to verify the nature of the image formed. (30-C1.3s)
2. Design an experiment that will produce measurements that can be used to determine the focal length of a concave mirror. (30-C1.1s, 30-C1.7k)
3. Design an experiment that will produce measurements that can be used to determine the focal length of a diverging lens or a convex mirror. How will the image be detected? (30-C1.1s, 30-C1.7k)
4. Research and report on real-world applications of converging/diverging lenses. (30-C1.2k, 30-C1.4s, 30-C1.2sts)
5. Explore the differences between thin and thick lenses. (30-C1.2sts)`