INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

**JUNE 1999**

## PROVINCIAL EXAMINATION

**MINISTRY OF EDUCATION**

# APPLICATIONS OF PHYSICS 12

### GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above and on the **back** cover of this booklet. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this booklet.**

2. Ensure that in addition to this examination booklet, you have an **Examination Response Form**. Follow the directions on the front of the Response Form.

3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.

4. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.

5. For each of the written-response questions, write your answer in the space provided in this booklet.

6. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

   **END OF EXAMINATION**.

7. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

**THIS PAGE INTENTIONALLY BLANK**

# APPLICATIONS OF PHYSICS 12 PROVINCIAL EXAMINATION

1. This examination consists of **two** parts:

| | | Value | Suggested Time |
|---|---|---|---|
| PART A: | 36 multiple-choice questions worth one mark each | 36 | 60 |
| PART B: | 9 written-response questions | 36 | 60 |
| | **Total:** | **72 marks** | **120 minutes** |

2. Aside from an approved calculator, electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.

3. Calculators should be set to degree mode.

4. The last **three** pages inside the back cover contain the **Table of Constants**, **Conversion Factors**, **Mathematical Equations**, **Formulae,** and **Rough Work for Multiple-Choice**. These pages may be detached for convenient reference prior to writing this examination.

5. Rough-work space has been incorporated into the space allowed for answering each written-response question. You may not need all of the space provided to answer each question.

6. **A calculator is essential for the Applications of Physics 12 Provincial Examination.** The calculator must be a hand-held device designed primarily for mathematical computations involving logarithmic and trigonometric functions and may be capable of performing graphing functions. Computers, calculators with a QWERTY keyboard, and electronic writing pads will not be allowed. Students must not bring any external devices to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, or external keyboards. Students may have more than one calculator available during the examination. Calculators may not be shared and must not have the ability to either transmit or receive electronic signals. In addition to an approved calculator, students will be allowed to use rulers, compasses, and protractors during the examination.

7. a) Numerical final answers must include appropriate **units**.
   b) Marks will not be deducted for answers expressed to **two** or **three** significant figures.
   c) In this examination the zero in a number such as 30 shall be considered to be a significant zero.

8. You are expected to communicate your knowledge and understanding in a clear and logical manner. With respect to questions requiring you to "explain" an answer, the explanation may be demonstrated by using calculations. Partial marks will be awarded for steps and assumptions leading to a solution. Full marks will **not** be awarded for providing **only** a final answer.

   If you are unable to determine the value of a quantity required in order to proceed, you may assume a reasonable value and continue toward the solution. Such a solution, however, may not be eligible for full marks.

9. The time allotted for this examination is **two hours**.

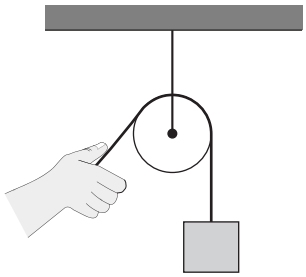
**THIS PAGE INTENTIONALLY BLANK**

## PART A: MULTIPLE CHOICE

**Value: 36 marks** **Suggested Time: 60 minutes**

**INSTRUCTIONS:** For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. A single fixed pulley

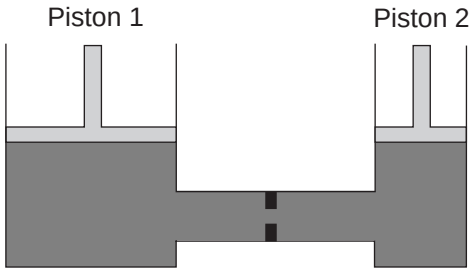


A. divides the effort force by two.
B. multiplies the efficiency by two.
C. multiplies the effort force by two.
D. changes the direction of the effort force.

2. A pulley system has an ideal mechanical advantage of $3.0$. If the actual mechanical advantage is $2.5$, what is the efficiency of the system?

A. $0.17$
B. $0.20$
C. $0.83$
D. $1.2$

3. When compared to those on piston 1, what would be the pressure and force on piston 2?




| | PRESSURE | FORCE |
|---|---|---|
| A. | equal | less |
| B. | equal | greater |
| C. | greater | less |
| D. | greater | equal |

**OVER**

4. A $2.0\ \text{m}$ high tank with a $4.0\ \text{m} \times 4.0\ \text{m}$ base is filled with gasoline and rests on a wooden floor. The pressure on the floor is $1\,360\ \text{N/m}^2$. Another $2.0\ \text{m}$ high tank is also filled with gasoline; however, its base is only $2.0\ \text{m} \times 2.0\ \text{m}$. What pressure does the smaller tank exert on the floor?

   A. $340\ \text{N/m}^2$
   B. $680\ \text{N/m}^2$
   C. $1\,360\ \text{N/m}^2$
   D. $2\,720\ \text{N/m}^2$

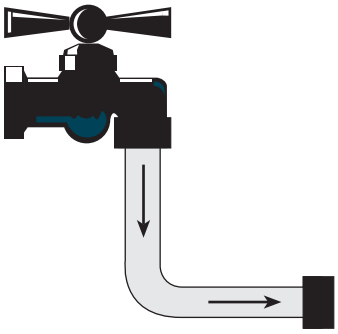
5. An electronic appliance requires $5.0\ \text{V}$ in order to operate. A transformer is used to change $120\ \text{V}$ from a household circuit to $5.0\ \text{V}$. If the primary has $250$ turns, how many turns should the secondary have and what type of transformer is this?

| | # OF TURNS | TYPE OF TRANSFORMER |
|---|---|---|
| A. | 10 | step-down |
| B. | 10 | step-up |
| C. | 6 000 | step-down |
| D. | 6 000 | step-up |

6. Which of the following statements about ideal transformers is **true**?

   A. A transformer steps up or steps down energy.
   B. A transformer functions best with a steady dc current.
   C. A transformer that steps up the voltage steps up the current.
   D. A transformer that steps up the voltage steps down the current.

7. Water rushes down a pipe as shown in the diagram below.



At the bend in the pipe, the direction of the (average) impulse that the pipe exerts on the water is best shown by which vector?

A.  B.  C.  D. 

8. A $200\ g$ arrow travelling at $35\ m/s$ travels through an apple. If the arrow's speed was reduced to $28\ m/s$ in $0.022$ seconds, what was the magnitude of the average force exerted by the apple on the arrow?

A. 64 N
B. 250 N
C. 320 N
D. 64 000 N

9. A truck collides with a stationary compact car. The car moves forward and rotates. What causes the rotation of the car?

A. The truck's mass is much larger than the car's mass.
B. The moment of inertia of the truck is greater than that of the car.
C. The impulse given the car is much greater than the impulse given the truck.
D. The centre-of-mass of the truck does not collide in line with the centre-of-mass of the car.

**OVER**

10. A freely spinning grinding wheel has an initial speed of $560$ rad/s. The radius is $8$ cm and the moment of inertia is $1.3\times10^{-3}\ \text{kg}\cdot\text{m}^2$. A $17$ N force of friction is applied to the rim. In how many seconds will the grinding wheel stop?

    A. $0.24$ s
    B. $0.54$ s
    C. $1.9$ s
    D. $99$ s

11. A skater is spinning with his arms outstretched. When he brings his arms close to his body, his

    A. angular momentum increases.
    B. angular velocity remains constant.
    C. angular momentum remains constant.
    D. angular momentum and angular velocity remain constant.

12. A device that transforms mechanical energy into electrical energy is a(n)

    A. battery.
    B. generator.
    C. steam engine.
    D. electric motor.

13. A $15\mu\text{F}$ capacitor was fully charged by a $6.0$ V battery in $4.5$ seconds. The capacitor was then disconnected from the battery. The capacitor was later discharged and found to have $1.2\times10^{-4}$ J of energy. What was the efficiency of the capacitor in storing energy?

    A. 22%
    B. 44%
    C. 56%
    D. 88%

14. An accelerometer could be made with a simple spring-mass system or a piezoelectric crystal. The main advantage of the piezoelectric crystal is that it

    A. provides an ac response.
    B. has no temperature dependence.
    C. can be used at higher frequencies.
    D. can be used at higher temperatures.

15. Different forces were applied to an electrical strain gauge. The following resistances were observed for the given forces:

| FORCE (N) | RESISTANCE ($\Omega$) |
|---|---|
| 500 N | 0.046 |
| 840 N | 0.068 |

What applied force would yield a resistance of $0.083\ \Omega$?

A. 570 N
B. 900 N
C. 1 000 N
D. 1 100 N

16. A galvanometer has an internal resistance of $12\ \Omega$ and a current sensitivity of $10\ \text{mA}$. To change it into a voltmeter with a range from $0$ to $3.0\ \text{V}$, use

A. 290 $\Omega$ in series.
B. 300 $\Omega$ in series.
C. 290 $\Omega$ in parallel.
D. 300 $\Omega$ in parallel.

17. Consider the following table.

| COEFFICIENTS OF THERMAL EXPANSION $(\text{C}^\circ)^{-1}$ | |
|---|---|
| Aluminum | $23\times10^{-6}$ |
| Brass | $19\times10^{-6}$ |
| Copper | $17\times10^{-6}$ |
| Lead | $29\times10^{-6}$ |
| Nickel | $13\times10^{-6}$ |
| Steel | $12\times10^{-6}$ |

Which combination of metals would produce the greatest bend in a bimetallic strip?

A. Lead/Steel
B. Nickel/Steel
C. Brass/Copper
D. Aluminum/Lead

**OVER**

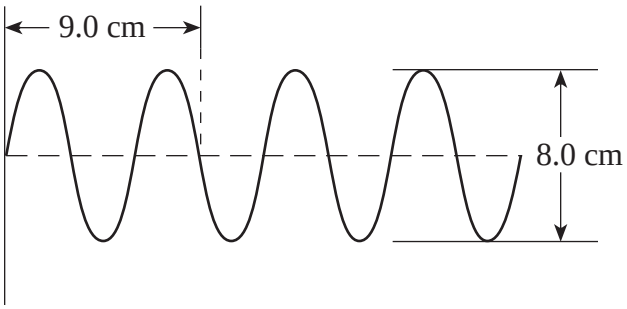
18. In an iron-constantan thermocouple, with one junction held at $0°C$, the output voltage varies linearly from $0.0$ to $11.0$ mV as the temperature of the other junction is raised from $0°$ to $200°C$. Find the temperature of the variable junction when the thermocouple output is $4.2$ mV.

A. $18°C$
B. $46°C$
C. $76°C$
D. $120°C$

19. Which transducer contains a small piece of semi-conducting material having a resistance that decreases with increasing temperature?

A. thermistor
B. thermocouple
C. bimetallic strip
D. platinum resistance thermometer

20. The diagram shows a portion of a vibrating string. Waves are travelling along the string at 10 cm/s. What is the frequency of the wave?

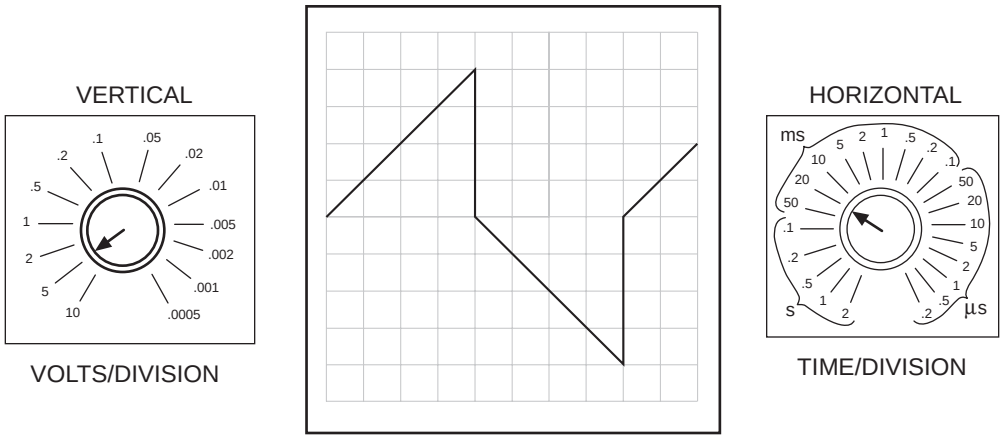



A. 1.1 Hz
B. 1.3 Hz
C. 1.7 Hz
D. 3.3 Hz

21. A standing wave is a result of

A. diffraction.
B. interference.
C. polarization.
D. Doppler shift.

22. Determine the amplitude for the wave shown below.




A. 20 V
B. 40 V
C. 80 ms
D. 160 ms

23. An object vibrates back and forth 20 times in one minute. What is its period of motion?

A. 0.33 s
B. 3.0 s
C. 20 s
D. 1 200 s

24. High frequency sound waves are directed at an artery. Reflected waves have a different frequency than incident waves due to the movement of the blood cells in an artery. From this difference, the speed of blood cells can be determined. This is an application of

A. diffraction.
B. interference.
C. polarization.
D. Doppler shift.

25. How does the maximum reception distance of the signal and the amount of static in the signal of FM radio transmission compare to AM radio transmission?

| | MAXIMUM DISTANCE | AMOUNT OF STATIC |
|---|---|---|
| A. | less | less |
| B. | more | less |
| C. | less | more |
| D. | more | more |

**OVER**

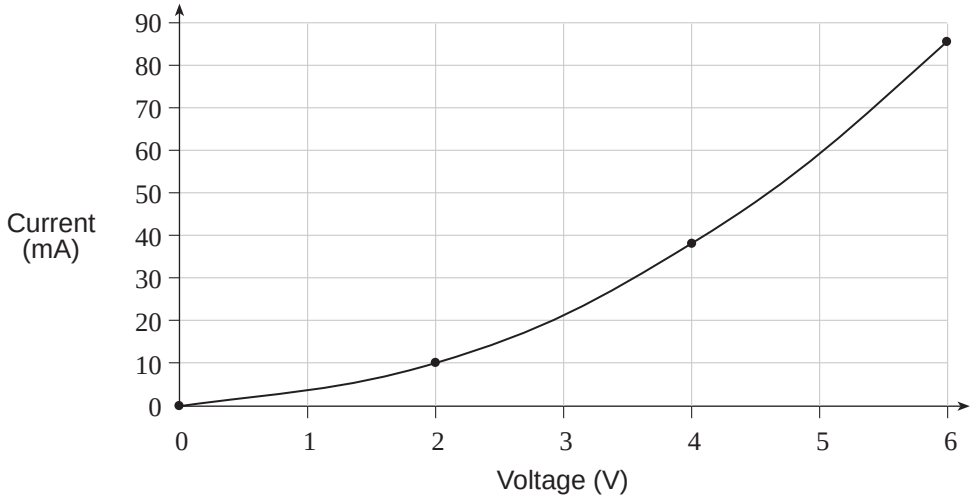
26. The critical angle for water is $49°$. Total internal reflection occurs when light travels from

A. air toward water at an angle of incidence less than $49°$.
B. air toward water at an angle of incidence greater than $49°$.
C. water toward air at an angle of incidence less than $49°$.
D. water toward air at an angle of incidence greater than $49°$.

27. A ray of light travelling through the air strikes the face of a glass surface at an angle of $53°$ with respect to the normal. If the angle of refraction is observed to be $30°$, what is the index of refraction of the glass? (Air has an index of refraction of $1.0$.)

A. $0.63$
B. $1.5$
C. $1.6$
D. $1.8$

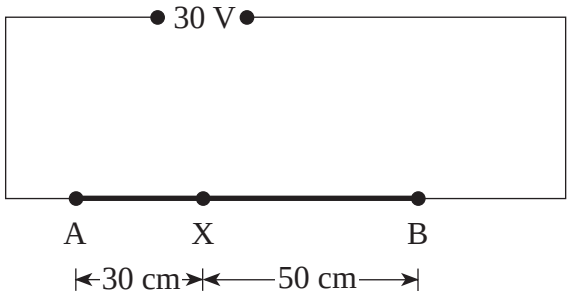
28. A student changed the voltage being applied to a miniature light bulb and measured the resulting current. The graph below shows the current as a function of voltage for the bulb.




When the voltage is $3.0$ V, what is the power of the miniature light bulb?

A. 15 mW
B. 20 mW
C. 28 mW
D. 60 mW

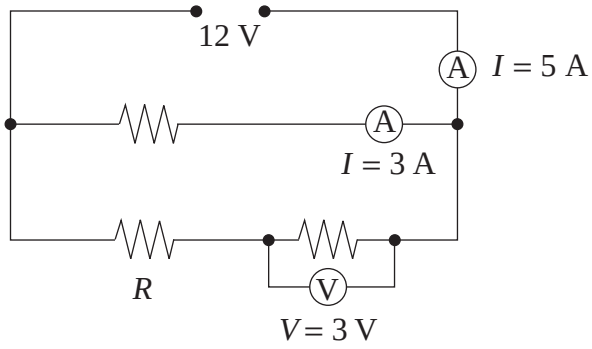
29. The circuit below contains a uniform resistance wire AB connected by wires of negligible resistance to a 30 V power source.




What is the voltage between points A and X?

A. 9.0 V
B. 11 V
C. 18 V
D. 19 V

30. Consider the following circuit:

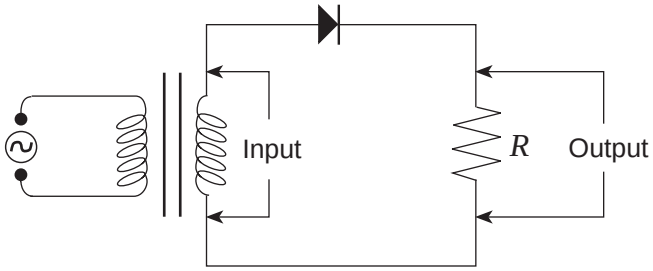



Determine the current through and the voltage across the resistor *R*.

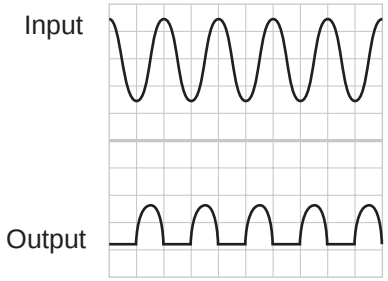
| | CURRENT | VOLTAGE |
|---|---|---|
| A. | 2 A | 3 V |
| B. | 2 A | 9 V |
| C. | 3 A | 3 V |
| D. | 3 A | 9 V |

**OVER**

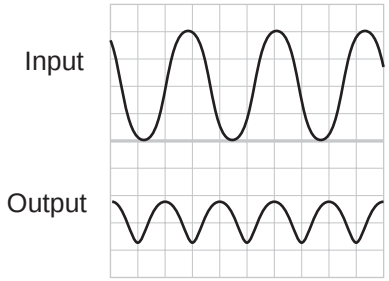
31. Which diagram of a dual-trace oscilloscope shows the input and output signals for the circuit shown?



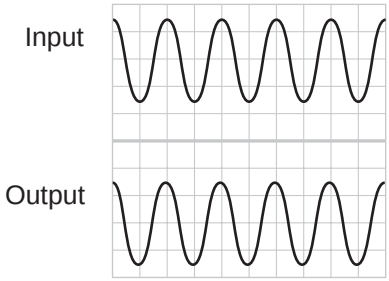

A.



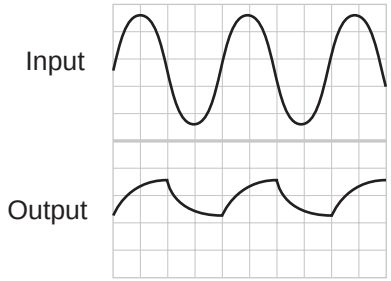

B.



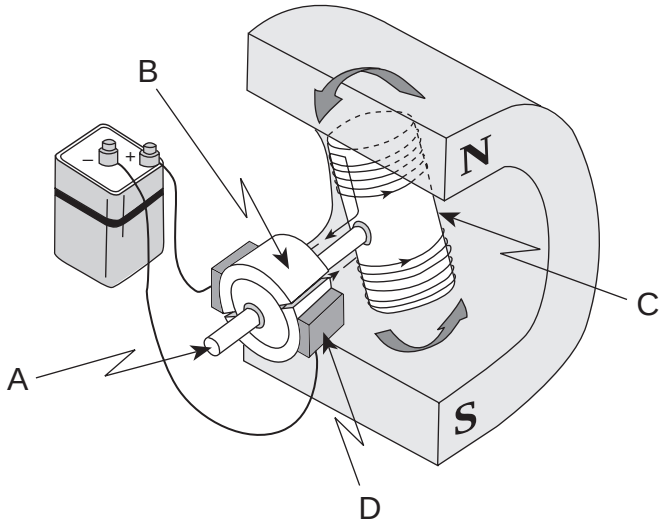

C.




D.

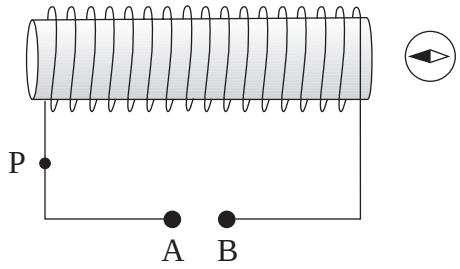



32. Which arrow indicates the commutator for the dc motor shown below?




A. A
B. B
C. C
D. D

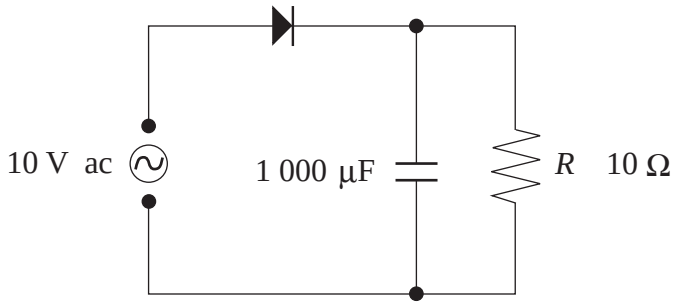
33. The diagram below shows a power source (AB), a solenoid and a compass. The north end of the compass points to the left.




Which terminal, A or B, of the power source is positive and in which direction do electrons flow through the circuit at point P?

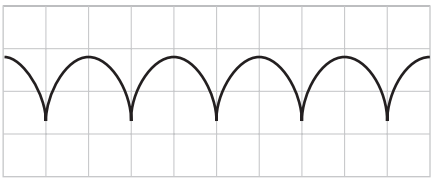
| | POSITIVE END | ELECTRON FLOW |
|---|---|---|
| A. | A | up |
| B. | A | down |
| C. | B | up |
| D. | B | down |

34. An oscilloscope is placed across the resistor in the circuit below.

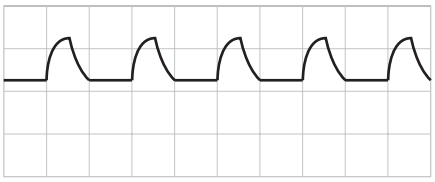



Which of the displays shown best represents the oscilloscope trace?

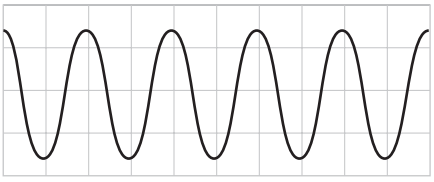
A.



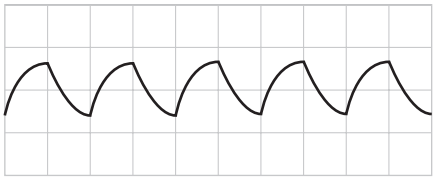
B.



C.

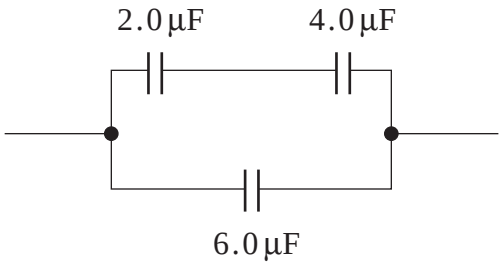


D.



**OVER**

35. Determine the equivalent capacitance of the circuit shown below.




A. $1.1\,\mu F$
B. $3.0\,\mu F$
C. $7.3\,\mu F$
D. $12\,\mu F$

36. A simple RC circuit consists of a $1.0\,\mu F$ capacitor, a $3.0\ k\Omega$ resistor, a $6.0\,V$ battery and an open switch in a series circuit. Initially the capacitor is uncharged. How long after the switch is closed will the voltage across the capacitor be $3.8\,V$?

A. $1.9\times10^{-3}$ s
B. $3.0\times10^{-3}$ s
C. $0.63$ s
D. $3.0$ s

**This is the end of the multiple-choice section.**
**Answer the remaining questions directly in this examination booklet.**

## PART B: WRITTEN RESPONSE

**Value: 36 marks** **Suggested Time: 60 minutes**

**INSTRUCTIONS:**

1. Rough-work space has been incorporated into the space allowed for answering each written-response question. You may not need all of the space provided to answer each question.

2. a) Numerical final answers must include appropriate **units**.
   b) Marks will not be deducted for answers expressed to **two** or **three** significant figures.
   c) In this examination the zero in a number such as 30 shall be considered to be a significant zero.

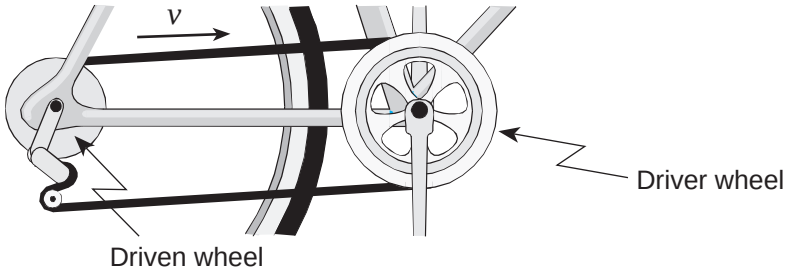
3. You are expected to communicate your knowledge and understanding of physics principles in a clear and logical manner. Partial marks will be awarded for steps and assumptions leading to a solution.

4. If you are unable to determine the value of a quantity required in order to proceed, you may assume a reasonable value and continue toward the solution. Such a solution, however, may not be eligible for full marks.

5. **Full marks will NOT be awarded for providing only a final answer.**

**OVER**

1. The driver wheel of a bicycle has 32 teeth.




a) How many teeth should the driven wheel have, if the speed mechanical advantage is to be approximately $3.5$? (Force mechanical advantage is $\frac{1}{3.5}$) **(2 marks)**

b) The radius of the driver wheel is 12 cm. What should the radius of the driven wheel be?

**(2 marks)**

ANSWER:

a) number of teeth: _____

b) radius of driven wheel: _____

**OVER**

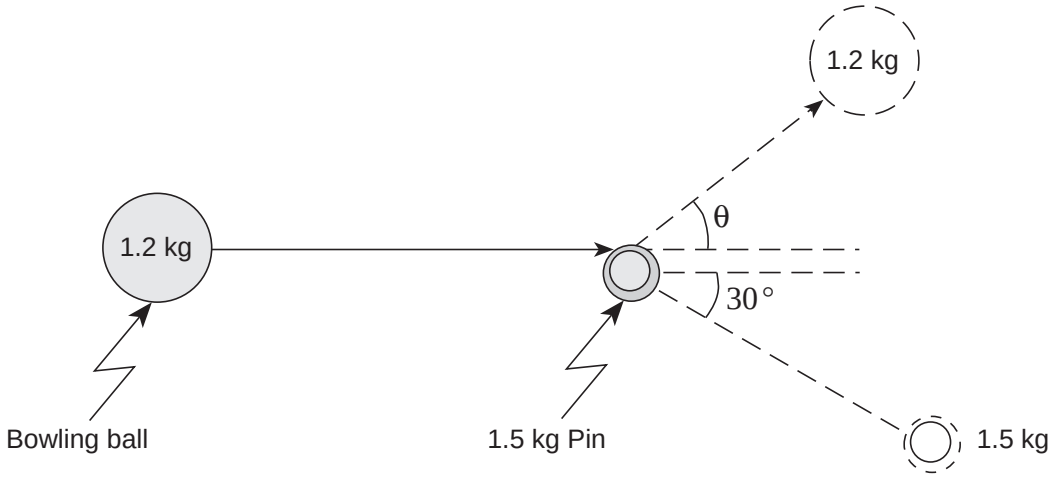
2. a) An induction coil uses current that is

❒ ac.
❒ dc.

(Check one response.) **(1 mark)**

b) Explain how an induction coil uses this current to produce a change in the magnetic field through the primary coil. **(2 marks)**

3. A 1.2 kg bowling ball moving at 14 m/s strikes a 1.5 kg pin at an angle. The pin moves off at 8 m/s at an angle of 30° as shown in the diagram.




What is the velocity (magnitude and direction) of the bowling ball after striking the pin?

**(5 marks)**

ANSWER:

velocity: _____

**OVER**

4. The giant blades of a wind turbine turn through two revolutions each second. This turbine turns an electric generator to produce 15 kW of power. The energy conversion is 70% efficient.

   a) What total torque is the wind applying to the blades of the turbine? **(2 marks)**

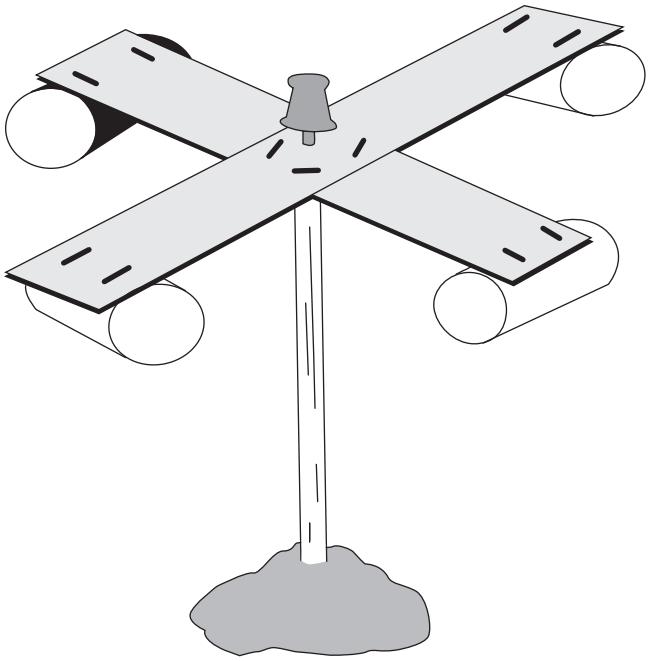
   b) How long does it take to generate 77 MJ of energy? **(2 marks)**

ANSWER:

a) torque: _____

b) time: _____

5. A student made the device shown below to measure wind speed. The materials used were: rimless paper cups (one painted black), cardboard strips, a wooden dowel, a tack, modelling clay.



Describe and explain the steps you would follow in order to determine wind speed in metres per second. **(4 marks)**

**OVER**

6. In a pipe closed at one end, resonance produces maximum sound intensity at the following lengths.

$L = \frac{\lambda}{4}$ $L = \frac{3\lambda}{4}$ $L = \frac{5\lambda}{4}$ where $L$ = length of pipe

a) Determine the lowest resonant frequency for a pipe of length 80 cm. **(3 marks)**

b) For the frequency determined in part a), at what pipe lengths is the sound intensity a minimum? **(2 marks)**

ANSWER:

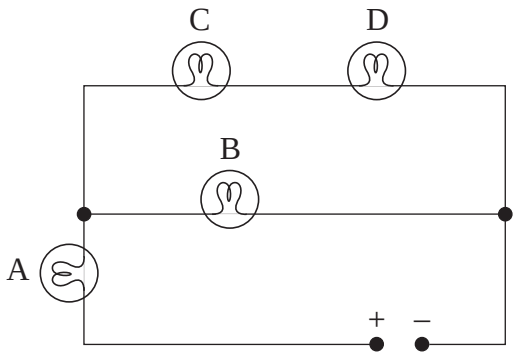
a) frequency: _____

b) lengths: _____

7. State how light from a laser differs from light from a typical lamp. **(3 marks)**

**OVER**

8. Four identical bulbs are connected to a fixed voltage source as shown.




Describe what would happen to the brightness of each of the other three bulbs if bulb D were unscrewed and removed from the socket. Explain the reason for your answer in each case. (Reasonable values for bulb resistance and a voltage source may be assumed in developing your explanation.) **(4 marks)**

9. Compare and contrast the operation of an electric motor with that of an electric generator.

**(4 marks)**

**END OF EXAMINATION**

**THIS PAGE INTENTIONALLY BLANK**

## TABLE OF CONSTANTS

| | | |
|---|---|---|
| Speed of light in vacuum | $c$ | $= 3.00 \times 10^8$ m/s |
| Acceleration due to gravity at the surface of Earth (for the purposes of this examination) | $g$ | $= 9.80$ m/s$^2$ $= 32.2$ ft/s$^2$ |
| Atmospheric pressure at sea level | | $= 1.013 \times 10^5$ Pa $= 14.70$ lb/in$^2$ |
| Density of air ($0°$C, 1 atm pressure) | | $= 1.29$ kg/m$^3$ |
| Speed of sound in air ($20°$C) | | $= 343$ m/s |
| Density of water ($4°$C) | | $= 1.00 \times 10^3$ kg/m$^3$ $= 62.4$ lb/ft$^3$ |
| Elementary charge unit | $e$ | $= 1.6 \times 10^{-19}$ C |
| Specific heat capacity of water | | $= 4\,186$ J/(kg·C°) |

## CONVERSION FACTORS

*Length*

1 in = 2.54 cm
1 ft = 0.3048 m
1 mi = 5 280 ft = 1.609 km
1 m = 3.281 ft
1 km = 0.6214 mi

*Mass*

1 slug = 14.59 kg

*Force*

1 lb = 4.448 N
1 N = $10^5$ dynes = 0.2248 lb

*Work and Energy*

1 J = 0.7376 ft·lb = $10^7$ ergs
1 kcal = 4 186 J
1 Btu = 1 055 J

*Power*

1 hp = 550 ft·lb/s = 745.7 W
1 W = 0.7376 ft·lb/s

*Pressure*

1 Pa = 1 N/m$^2$ = $1.450 \times 10^{-4}$ lb/in$^2$
1 lb/in$^2$ = $6.895 \times 10^3$ Pa
1 atm = $1.013 \times 10^5$ Pa = 1.013 bar = 14.70 lb/in$^2$ = 760 torr

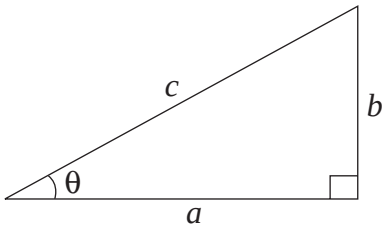
*Volume*

1 litre = $10^{-3}$ m$^3$ = 1 000 cm$^3$ = 0.03531 ft$^3$
1 ft$^3$ = 0.02832 m$^3$ = 7.481 U.S. gallons
1 U.S. gallon = $3.785 \times 10^{-3}$ m$^3$ = 0.1337 ft$^3$

*Angle*

1 radian = 57.30°
1° = 0.01745 radian

**For Right-angled Triangles:**

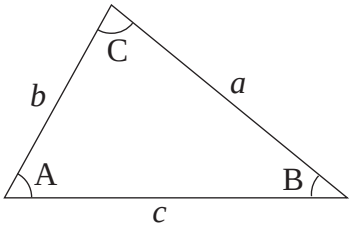



$$a^2 + b^2 = c^2$$

$$\sin\theta = \frac{b}{c} \qquad \cos\theta = \frac{a}{c} \qquad \tan\theta = \frac{b}{a}$$

$$\text{area} = \frac{1}{2}\,ab$$

**For All Triangles:**




$$\text{area} = \frac{1}{2}\ \text{base} \times \text{height}$$

**Sine Law**: $\dfrac{\sin A}{a} = \dfrac{\sin B}{b} = \dfrac{\sin C}{c}$

**Cosine Law**: $c^2 = a^2 + b^2 - 2\,ab\ \cos C$

**Circle:**

$$\text{Circumference} = 2\pi r$$

$$\text{Area} = \pi r^2$$

**Metric Prefixes:**

| | | | | | |
|---|---|---|---|---|---|
| $10^{12}$ | tera | T | $10^{-2}$ | centi | c |
| $10^{9}$ | giga | G | $10^{-3}$ | milli | m |
| $10^{6}$ | mega | M | $10^{-6}$ | micro | μ |
| $10^{3}$ | kilo | k | $10^{-9}$ | nano | n |
| $10^{2}$ | hecto | h | $10^{-12}$ | pico | p |
| $10^{-1}$ | deci | d | $10^{-15}$ | femto | f |

## FORMULAE

$d = v_0 t + \frac{1}{2} a t^2$
$v = v_0 + at$

$\theta = \theta_0 t + \frac{1}{2} \alpha t^2$
$\omega = \omega_0 + \alpha t$

$\tau = F \cdot d$

$I_{disk} = \frac{1}{2} mr^2$

$F_{net} = ma$
$p = mv$
$F\Delta t = \Delta p$

$\tau_{net} = I\alpha$
$L = I\omega$
$\tau\Delta t = \Delta L$

$F_f = \mu F_N$
$F = kx$

$W = F \cdot d$

$W = \tau \cdot \theta$

$E_k = \frac{1}{2} mv^2$
$E_p = mgh$
$E_p = \frac{1}{2} kx^2$
$E_H = mc\Delta T$

$E_k = \frac{1}{2} I\omega^2$

$P = \frac{W}{t}$

$P = \frac{F}{A}$

$\Delta P = \rho g h$

$W = \Delta(PV)$

$f = \frac{1}{T}$
$v = f\lambda$

$n = \frac{c}{v}$
$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$I = \frac{Q}{t}$
$V = IR$

$V = \frac{\Delta Ep}{Q}$
$P = IV$

$R = \rho \frac{L}{A}$

$\frac{V_{out}}{V_{in}} = \frac{N_{out}}{N_{in}} = \frac{I_{in}}{I_{out}}$

$C = \frac{Q}{V}$
$V = V_0 e^{-\frac{t}{\tau}}$

$\tau = RC$
$E_p = \frac{1}{2} CV^2$

## ROUGH WORK FOR MULTIPLE-CHOICE

**You may detach this page for convenient reference.**
**Exercise care when tearing along perforations.**

INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

# APPLICATIONS OF PHYSICS 12

## June 1999

Course Code = PHA

FOR OFFICE USE ONLY

# APPLICATIONS OF PHYSICS 12

## June 1999

Course Code = PHA

| Score for Question 1: | Score for Question 8: |
|---|---|
| 1. _____ (4) | 8. _____ (4) |

| Score for Question 2: | Score for Question 9: |
|---|---|
| 2. _____ (3) | 9. _____ (4) |

| Score for Question 3: |
|---|
| 3. _____ (5) |

| Score for Question 4: |
|---|
| 4. _____ (4) |

| Score for Question 5: |
|---|
| 5. _____ (4) |

| Score for Question 6: |
|---|
| 6. _____ (5) |

| Score for Question 7: |
|---|
| 7. _____ (3) |