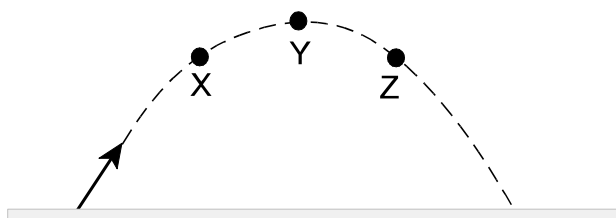


**PART I**  
**Total Value: 50%**

**Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.**

1. Which represents the vertical component of the velocity at points X, Y and Z for the object following the parabolic path shown below?



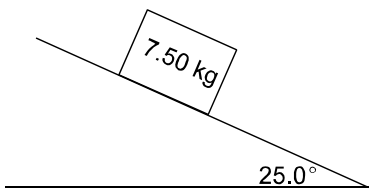
	X	Y	Z
(A)	downward	downward	downward
(B)	downward	zero	upward
(C)	upward	upward	upward
(D)	upward	zero	downward

2. What is the range of a ball thrown horizontally at 12 m/s if its time of flight is 3.0 s?
- (A) 0.25 m  
(B) 4.0 m  
(C) 12 m  
(D) 36 m
3. An arrow is fired from a bow with an initial velocity of 18.0 m/s at an angle of  $35.0^\circ$  above the horizontal. How far, horizontally, has the arrow travelled in 1.45 s?
- (A) 12.4 m  
(B) 15.0 m  
(C) 21.4 m  
(D) 26.1 m
4. A ball is launched with an initial velocity of 28.0 m/s at  $40.0^\circ$  above the horizontal. How long does it take for the ball to reach its maximum height?
- (A) 1.68 s  
(B) 1.84 s  
(C) 2.19 s  
(D) 2.86 s
5. A golf ball is launched at an angle of  $15.0^\circ$  from the ground. What was the initial speed of the ball if it lands on the ground 3.42 s later?
- (A) 16.8 m/s  
(B) 17.3 m/s  
(C) 64.7 m/s  
(D) 129 m/s

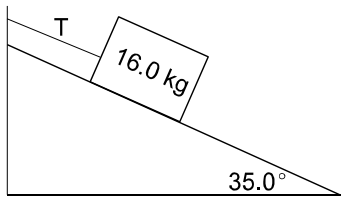
6. A cannonball is fired on Earth at an angle of  $45^\circ$  above the ground and has a range of 125 m. If the same cannonball is fired on Jupiter where  $g = 24.6 \text{ m/s}^2$ , which combination of changes would have to occur so that the cannonball still has a range of 125 m?

	Launch Angle	Launch Speed
(A)	decrease	same
(B)	increase	same
(C)	same	decrease
(D)	same	increase

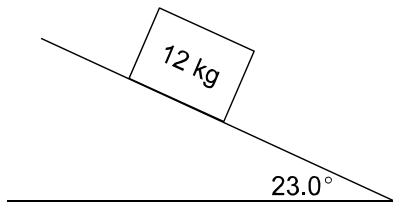
7. What is the normal force acting on the 7.50 kg box shown?



- (A) 3.17 N  
 (B) 6.80 N  
 (C) 31.1 N  
 (D) 66.6 N
8. A 16.0 kg box is held stationary on a frictionless incline as shown. What is the tension in the string?

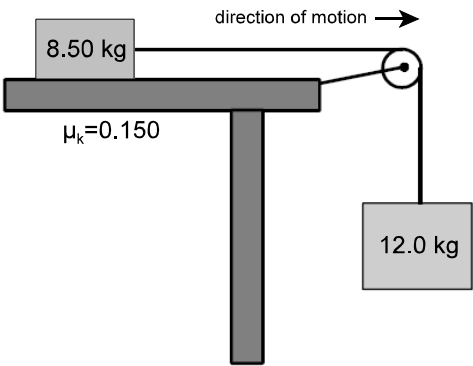


- (A) 22.2 N  
 (B) 89.9 N  
 (C) 128 N  
 (D) 157 N
9. What is the coefficient of kinetic friction for the incline shown if the 12 kg block is accelerating down the incline at  $1.15 \text{ m/s}^2$ ?

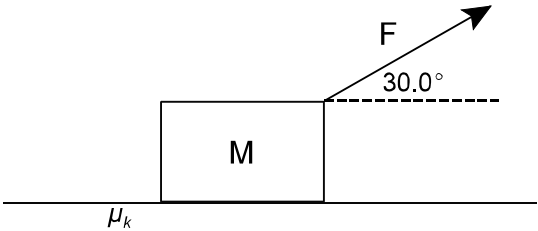


- (A) 0.30  
 (B) 0.42  
 (C) 0.70  
 (D) 0.87

10. What is the acceleration of the system shown if  $\mu_k = 0.150$ ?



- (A)  $1.67 \text{ m/s}^2$   
(B)  $5.13 \text{ m/s}^2$   
(C)  $8.76 \text{ m/s}^2$   
(D)  $12.4 \text{ m/s}^2$
11. A box of mass  $M$  is pulled at a constant speed on a horizontal surface with an applied force of  $F$  as shown. Which represents the coefficient of kinetic friction required to maintain a constant speed?



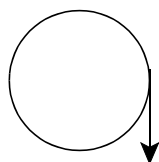
- (A)  $\frac{F \cos \theta}{Mg - F \sin \theta}$   
(B)  $\frac{F \sin \theta}{Mg - F \cos \theta}$   
(C)  $\frac{Mg - F \cos \theta}{F \sin \theta}$   
(D)  $\frac{Mg - F \sin \theta}{F \cos \theta}$
12. Which describes uniform circular motion?

	Speed	Velocity
(A)	changing	changing
(B)	changing	constant
(C)	constant	changing
(D)	constant	constant

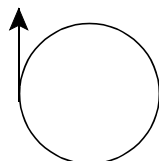
13. A circular race track has a radius of 159 m. If the centripetal force acting on a 65.0 kg cyclist is 4.16 N, how long does it take to complete one lap around the track?
- (A) 9.91 s  
(B) 98.2 s  
(C) 313 s  
(D) 785 s

14. Which shows the direction of the centripetal force acting on a mass spun in a vertical circle?

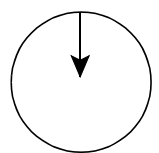
(A)



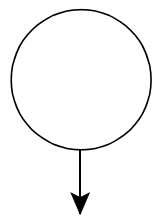
(B)



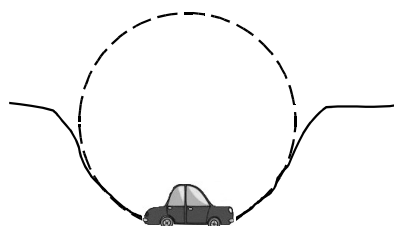
(C)



(D)



15. The diagram below represents a  $1.9 \times 10^3$  kg car driving into the bottom of a small valley. If the car is travelling at 9.0 m/s and the radius of the valley is 12.0 m, what is the normal force acting on the car?

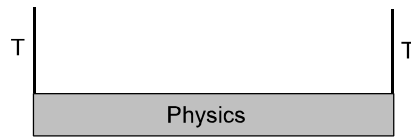


- (A)  $5.8 \times 10^3$  N  
(B)  $1.3 \times 10^4$  N  
(C)  $1.9 \times 10^4$  N  
(D)  $3.1 \times 10^4$  N
16. At what speed can a car safely negotiate a frictionless curve of radius 115 m if the road is banked at an angle of  $35.0^\circ$ ?
- (A) 8.97 m/s  
(B) 19.9 m/s  
(C) 28.1 m/s  
(D) 40.1 m/s

17. Which is an expression of torque?

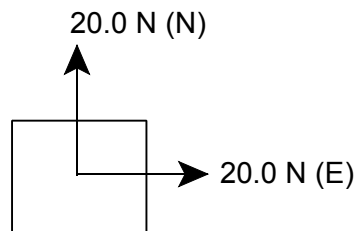
- (A)  $\tau = F \sin \theta \cdot r$
- (B)  $\tau = ma$
- (C)  $\tau = m\Delta v$
- (D)  $\tau = v \sin \theta$

18. What is the tension in each wire that supports the 10.0 kg sign shown?



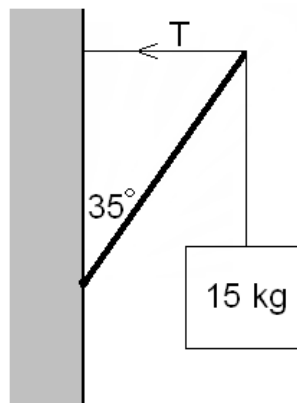
- (A) 5.00 N
- (B) 10.0 N
- (C) 49.0 N
- (D) 98.0 N

19. Which additional force is necessary for the object shown to be in static equilibrium?



- (A) 20.0 N [NE]
- (B) 20.0 N [SW]
- (C) 28.3 N [NE]
- (D) 28.3 N [SW]

20. A 15.0 kg sign is hung from a 3.0 m long beam of negligible mass and supported by a cable as shown. What tension is required in the cable to support the sign?



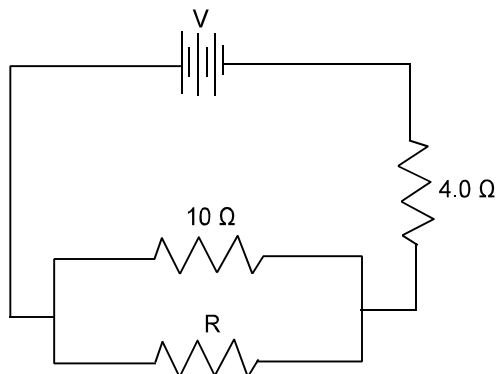
- (A)  $1.0 \times 10^2$  N
- (B)  $1.5 \times 10^2$  N
- (C)  $1.8 \times 10^2$  N
- (D)  $2.1 \times 10^2$  N

21. Which describes electric field lines?

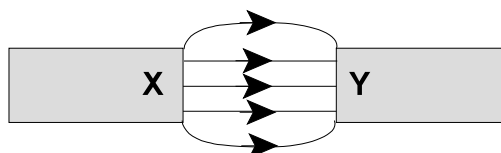
- (A) circle clockwise around positive charges
- (B) circle counterclockwise around positive charges
- (C) directed away from negative charges
- (D) directed toward negative charges

22. How many excess electrons reside on a metal sphere with a charge of  $-0.150\text{ C}$ ?
- (A)  $9.11 \times 10^{-31}$
  - (B)  $1.60 \times 10^{-19}$
  - (C)  $9.38 \times 10^{17}$
  - (D)  $6.24 \times 10^{18}$
23. What is the force between a  $1.50 \times 10^{-5}\text{ C}$  charge and a  $1.03 \times 10^{-5}\text{ C}$  charge that are separated by a distance of  $12.0\text{ m}$ ?
- (A)  $9.66 \times 10^{-3}\text{ N}$
  - (B)  $1.16 \times 10^{-1}\text{ N}$
  - (C)  $9.66 \times 10^9\text{ N}$
  - (D)  $1.16 \times 10^{11}\text{ N}$
24. What force is experienced by a  $2.50 \times 10^{-6}\text{ C}$  test charge placed in a  $2.92 \times 10^4\text{ N/C}$  electric field?
- (A)  $8.56 \times 10^{-11}\text{ N}$
  - (B)  $7.30 \times 10^{-2}\text{ N}$
  - (C)  $6.57 \times 10^8\text{ N}$
  - (D)  $1.17 \times 10^{10}\text{ N}$
25. How much work is done by a  $9.00\text{ V}$  power supply in moving  $8.50 \times 10^{18}$  electrons?
- (A)  $1.50 \times 10^{-1}\text{ J}$
  - (B)  $1.22 \times 10^1\text{ J}$
  - (C)  $9.44 \times 10^{17}\text{ J}$
  - (D)  $7.65 \times 10^{19}\text{ J}$
26. What is the instrument used to measure electric current?
- (A) ammeter
  - (B) galvanometer
  - (C) ohmmeter
  - (D) voltmeter
27. Which type of energy is converted to electrical energy using a piezo-electric device?
- (A) chemical
  - (B) light
  - (C) mechanical
  - (D) thermal
28. A  $6.0\ \Omega$  and a  $12\ \Omega$  resistor are connected in series to a  $36\text{ V}$  battery. What power is dissipated by the  $6.0\ \Omega$  resistor?
- (A)  $6.0\text{ W}$
  - (B)  $12\text{ W}$
  - (C)  $24\text{ W}$
  - (D)  $48\text{ W}$

29. What is the resistance of a 1.0 m long copper wire of radius 0.0051 m ( $\rho = 1.69 \times 10^{-8} \Omega \cdot \text{m}$ )?
- (A)  $1.1 \times 10^{-6} \Omega$   
 (B)  $3.3 \times 10^{-6} \Omega$   
 (C)  $2.1 \times 10^{-4} \Omega$   
 (D)  $1.2 \times 10^{-3} \Omega$
30. What value of R in the circuit below will cause the parallel combination to dissipate the same power as the 4.0  $\Omega$  resistor?

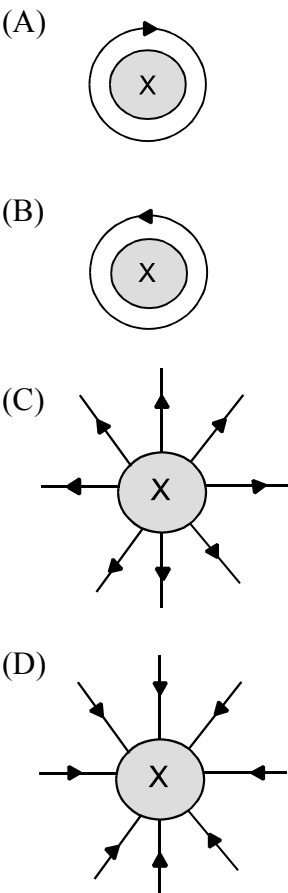


- (A) 0.26  $\Omega$   
 (B) 2.9  $\Omega$   
 (C) 6.0  $\Omega$   
 (D) 6.7  $\Omega$
31. Which is equivalent to 1 W?
- (A)  $1 \frac{\text{V}}{\text{A}}$   
 (B)  $1 \Omega \cdot \text{A}$   
 (C)  $1 \text{ V} \cdot \text{A}$   
 (D)  $1 \frac{\text{V}}{\Omega}$
32. What is the polarity of X and Y for the magnets shown below?



	X	Y
(A)	north	north
(B)	north	south
(C)	south	north
(D)	south	south

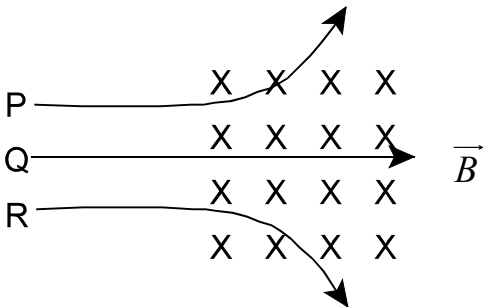
33. Which represents the magnetic field produced around the straight current-carrying conductor below?



34. What is the force on a 2.1 m long wire, carrying 0.56 A of current, placed perpendicularly in a  $4.6 \times 10^{-4}$  T magnetic field?

- (A)  $1.2 \times 10^{-4}$  N
- (B)  $5.4 \times 10^{-4}$  N
- (C)  $2.0 \times 10^{-3}$  N
- (D)  $8.2 \times 10^3$  N

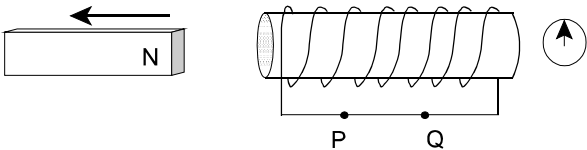
35. What are the charges on the three charged particles fired into the magnetic field as shown below?



	P	Q	R
(A)	negative	negative	positive
(B)	negative	neutral	positive
(C)	positive	neutral	negative
(D)	positive	positive	negative

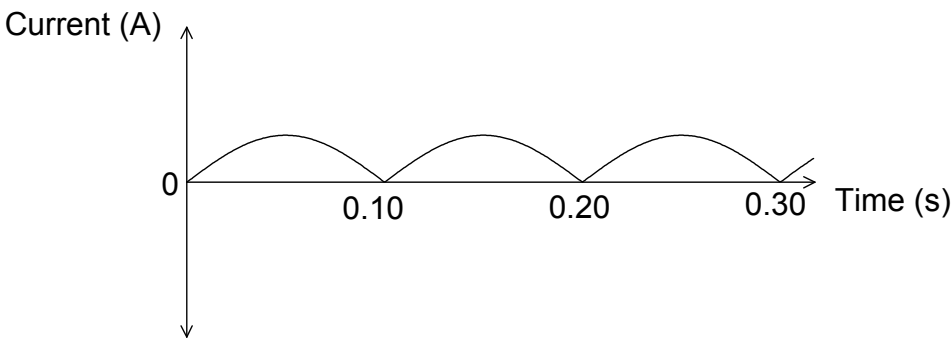


36. A current-carrying conductor is placed perpendicular to a magnetic field and experiences a force of magnitude,  $F_1$ . What will be the new force if the wire is placed at an angle of  $30.0^\circ$  to the magnetic field?
- (A)  $0.500 F_1$   
 (B)  $0.866 F_1$   
 (C)  $1.00 F_1$   
 (D)  $2.00 F_1$
37. At what distance from a wire carrying 3.5 A of current will the magnetic field strength be  $9.2 \times 10^{-3} \text{ T}$ ?
- (A)  $7.6 \times 10^{-7} \text{ m}$   
 (B)  $1.5 \times 10^{-6} \text{ m}$   
 (C)  $7.6 \times 10^{-5} \text{ m}$   
 (D)  $1.5 \times 10^{-4} \text{ m}$
38. What is the direction of current flow and compass deflection as the magnet is pulled left in the diagram shown?



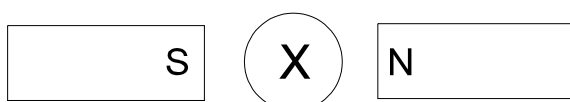
	Current Direction	Deflection of Compass
(A)	P to Q	left
(B)	P to Q	right
(C)	Q to P	left
(D)	Q to P	right

39. What is the type of generator and the frequency of rotation for the output shown below?



	Type	Frequency (Hz)
(A)	AC	5
(B)	AC	10
(C)	DC	5
(D)	DC	10

40. A conductor is initially at rest in a magnetic field as shown. In which direction should the conductor be moved so that current is induced as shown?



- (A) into the page  
(B) out of the page  
(C) towards bottom of the page  
(D) towards top of the page
41. How much energy is carried by a photon having frequency  $1.5 \times 10^{11}$  Hz?
- (A)  $1.4 \times 10^{-25}$  J  
(B)  $9.9 \times 10^{-23}$  J  
(C)  $3.0 \times 10^{-14}$  J  
(D)  $1.3 \times 10^{-3}$  J
42. A metal has a work function of 4.50 eV. What is the maximum kinetic energy of the ejected electrons if the wavelength of the incident light is  $2.50 \times 10^{-7}$  m?
- (A) 0.37 eV  
(B) 0.46 eV  
(C) 4.97 eV  
(D) 9.47 eV
43. A photon with energy  $E_0$  strikes a free electron. The photon is deflected in the opposite direction, with energy  $E$ . What is the resulting kinetic energy of the electron?
- (A)  $E_0$   
(B)  $E$   
(C)  $E_0 - E$   
(D)  $E_0 + E$
44. What is the frequency of a photon of light that has a momentum of  $2.80 \times 10^{-27}$  N·s?
- (A)  $2.37 \times 10^{-7}$  Hz  
(B)  $4.21 \times 10^{-6}$  Hz  
(C)  $4.23 \times 10^6$  Hz  
(D)  $1.27 \times 10^{15}$  Hz
45. What is the mass of an object thrown with a speed of 45 m/s and having a de Broglie wavelength of  $3.32 \times 10^{-34}$  m?
- (A) 0.011 kg  
(B) 0.044 kg  
(C) 22 kg  
(D) 88 kg
46. Which best explains why each atom in the periodic table has a unique set of spectral lines?
- (A) Each atom has a unique neutron to proton ratio.  
(B) Each atom has a unique set of energy levels.  
(C) The electrons in atoms are in constant motion.  
(D) The electrons in atoms orbit the nucleus.

47. Which transmutation is represented by the equation  ${}_{92}^{238}\text{U} \rightarrow {}_{90}^{234}\text{Th} + {}_2^4\text{He}$  ?

- (A) alpha decay
- (B) beta minus decay
- (C) beta positive decay
- (D) gamma decay

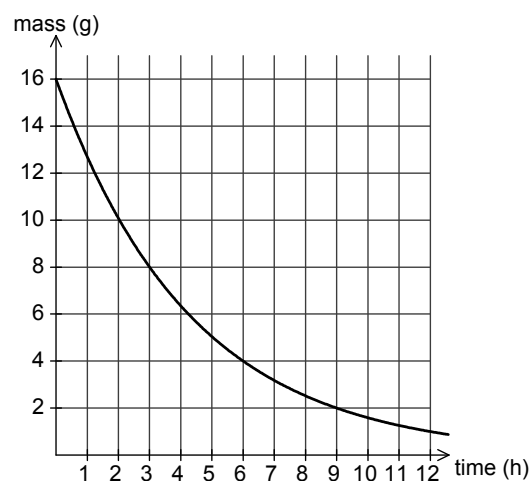
48. Which shows the beta minus ( $\beta^-$ ) decay of  ${}_{38}^{90}\text{Sr}$  ?

- (A)  ${}_{38}^{90}\text{Sr} \rightarrow {}_0^{-1}e + {}_{38}^{89}\text{Sr}$
- (B)  ${}_{38}^{90}\text{Sr} \rightarrow {}_{-1}^0e + {}_{39}^{90}\text{Y}$
- (C)  ${}_{38}^{90}\text{Sr} \rightarrow {}_0^{-1}e + {}_{38}^{91}\text{Sr}$
- (D)  ${}_{38}^{90}\text{Sr} \rightarrow {}_{-1}^0e + {}_{37}^{90}\text{Rb}$

49. A radioactive material has an initial activity of 1320 Bq. What is its activity after 9.0 h if its half-life is 3.2 h?

- (A)  $1.9 \times 10^2$  Bq
- (B)  $2.4 \times 10^2$  Bq
- (C)  $1.0 \times 10^3$  Bq
- (D)  $1.2 \times 10^3$  Bq

50. What is the half-life of the unknown substance shown?



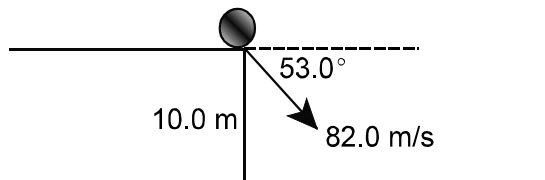
- (A) 2 h
- (B) 3 h
- (C) 8 h
- (D) 10 h

**PART II**  
**Total Value: 50%**

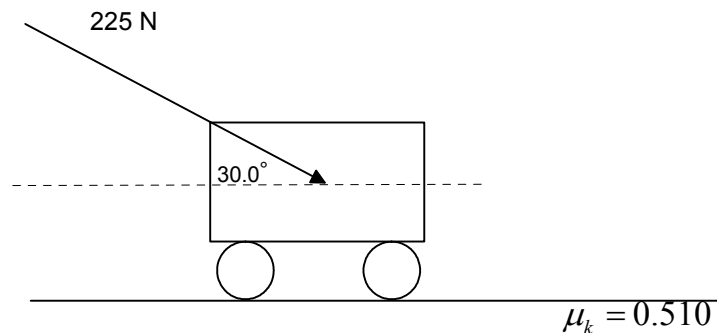
**Instructions:** Complete all items in this section. Your responses should be clearly presented in a well organized manner with proper use of units, formulae and significant figures where appropriate.

**Value**

- 4%      51.(a) A ball is thrown with an initial velocity of  $82.0 \text{ m/s}$  at an angle of  $53.0^\circ$  below the horizontal as shown. Calculate the range of the ball if it is thrown from a height of  $10.0 \text{ m}$ .



- 4%      (b) A  $23.5 \text{ kg}$  lawn mower is pushed with a force of  $225 \text{ N}$  as shown ( $\mu_k = 0.510$ ).



- i) Draw a free body diagram for the lawn mower.
- ii) Calculate the magnitude of the acceleration of the lawn mower.

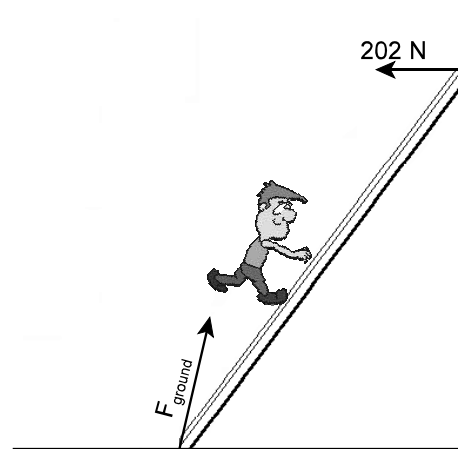
**Value**

3%      51.(c) A 2.00 kg object is attached to the end of a 3.00 m long rope and is spun in a vertical circle. Calculate the speed of the object, at the bottom of the circle, if the tension in the rope is 49.0 N.

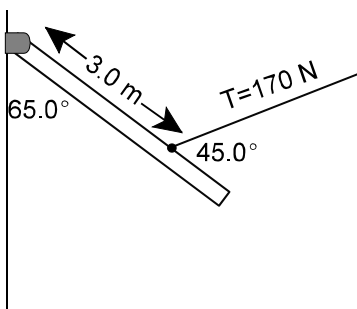
3%      (d) A 1500 kg car rounds a curve on a flat road of radius 55 m at a speed of 16 m/s. Determine whether the car will make the turn on an icy road where  $\mu = 0.20$ . Show your calculations.

**Value**

- 3% 51.(e) A 65.0 kg person stands on a uniform ladder of mass 7.0 kg. The ladder leans against a frictionless wall as shown. The wall exerts a 202 N force on the ladder as shown. Calculate the magnitude of the force that the ground exerts on the ladder.

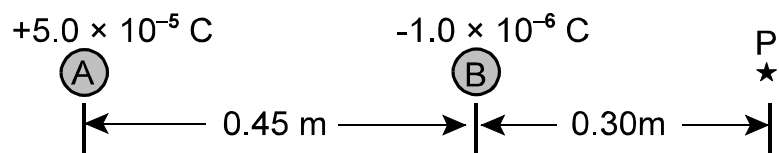


- 3% (f) A 4.0 m long uniform beam is supported 3.0 m from a hinge by a cable as shown. If the tension in the cable is 170 N, calculate the mass of the beam.

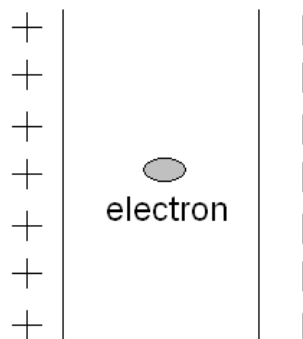


Value

4% 52.(a) Calculate the net electric field at point P in the diagram shown.



3% (b) An electron is placed between two oppositely charged parallel plates with an electric field strength of  $2.7 \times 10^4 \text{ N/C}$  and accelerates horizontally toward one of the plates.

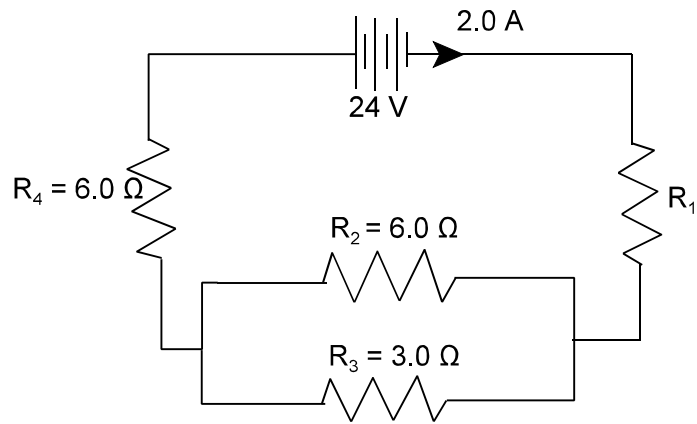


i) Calculate the acceleration of the electron.

ii) Calculate the speed of the electron after it has travelled  $0.22 \text{ m}$ .

**Value**

5% 52.(c) In the circuit shown, calculate:



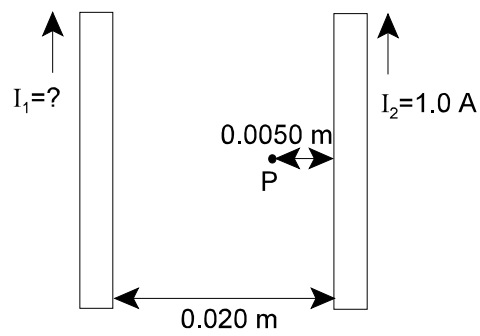
- i) the voltage for  $R_4$ .
- ii) the value of  $R_1$ .
- iii) the power dissipated in  $R_3$ .



**Value**

- 2% 52.(d) A  $75\ \Omega$  resistor that is  $0.28\ \text{m}$  long is placed in a uniform magnetic field of  $0.25\ \text{T}$ . If the resistor experiences a force of  $4.0 \times 10^{-2}\ \text{N}$  when it is perpendicular to the magnetic field, calculate the voltage across the resistor.

- 3% (e) Calculate  $I_1$  so that the net magnetic field at point P is zero.



**Value**

- 3%      52.(f) An electron is projected perpendicularly into a  $3.00 \times 10^{-2}$  T magnetic field and travels in a circle with radius  $7.5 \times 10^{-3}$  m. Calculate the minimum velocity required to maintain the circular path.
- 3%      53.(a) The stopping potential of a metal is 2.4 V. Calculate the work function if light incident on the metal has a wavelength of  $4.0 \times 10^{-7}$  m.
- 3%      (b) A light source of wavelength  $\lambda$  illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.00 eV. A second light source of wavelength  $\frac{\lambda}{2}$  shines on the same metal and ejects photoelectrons with a maximum kinetic energy of 4.00 eV. Calculate the work function of the metal.

Value

2%      53.(c)    Use Bohr energy levels to explain fluorescence and phosphorescence.

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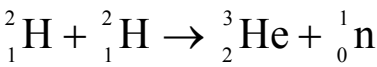
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2%      (d)      Calculate the energy, in Joules, released in the reaction shown below.



Particle	Mass (u)
${}^2_1\text{H}$	2.014102
${}^1_0\text{n}$	1.008665
${}^3_2\text{He}$	3.01603