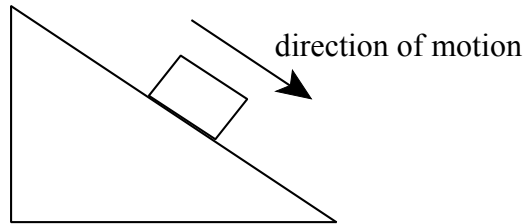


**PART I**  
**Total Value: 50%**

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

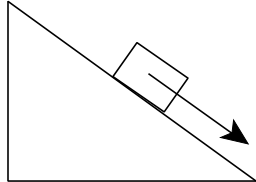
1. A rock is thrown horizontally off the roof of a building at 18 m/s. What is the horizontal component of the velocity just before the rock hits the ground?  
  
(A) -18 m/s  
(B) -9.8 m/s  
(C) 9.8 m/s  
(D) 18 m/s
  
2. A juggler throws a ball at 0.22 m/s at an angle of  $60.0^\circ$  above the horizontal. What is the y-component of the velocity of the ball?  
  
(A) 0.11 m/s  
(B) 0.19 m/s  
(C) 0.25 m/s  
(D) 0.44 m/s
  
3. How much time does it take a soccer ball to travel 50.0 m horizontally if it is kicked with a velocity of 18.4 m/s at an angle of  $30.0^\circ$  above the horizontal?  
  
(A) 0.184 s  
(B) 0.319 s  
(C) 3.14 s  
(D) 5.43 s
  
4. A ball is thrown horizontally with a speed of 10.0 m/s. If it hits the ground 4.0 s later, what is the magnitude of the y-component of its velocity just before it hits the ground?  
  
(A) 0 m/s  
(B) 39 m/s  
(C) 49 m/s  
(D) 98 m/s
  
5. Which expression represents the time it takes for a projectile, with initial velocity  $v_1$ , at angle  $\theta$  above the horizontal, to reach its maximum height?  
  
(A)  $v_1 g \cos \theta$   
(B)  $v_1 g \sin \theta$   
(C)  $\frac{v_1 \cos \theta}{g}$   
(D)  $\frac{v_1 \sin \theta}{g}$

6. In the diagram below, a box is sliding down a frictionless inclined plane.

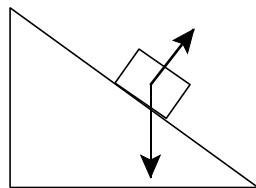


Which free body diagram best represents this situation?

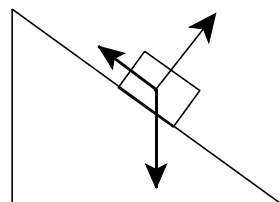
(A)



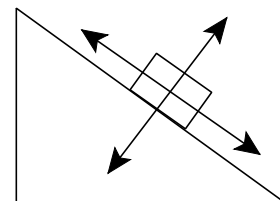
(B)



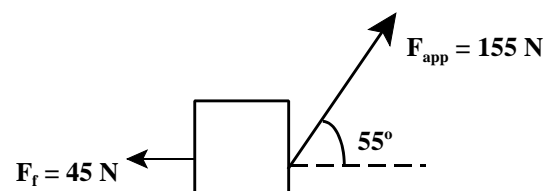
(C)



(D)

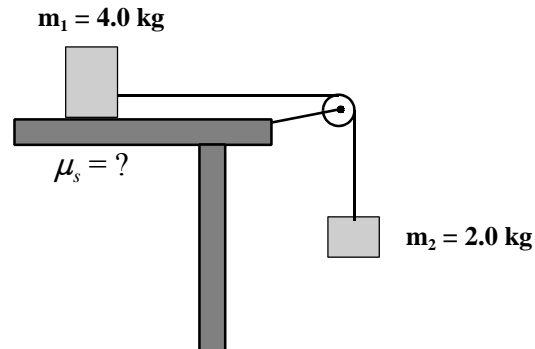


7. What is the magnitude of the net horizontal force acting on the object below?

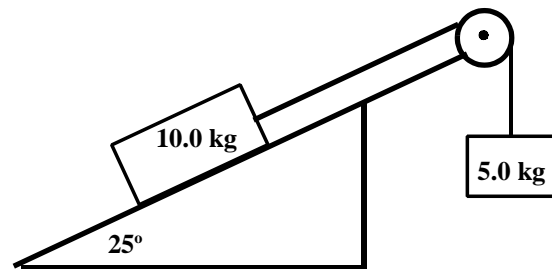


- (A) 44 N  
(B) 82 N  
(C) 110 N  
(D) 130 N
8. What is the force of friction on a 10.0 kg object sliding at a constant speed along a horizontal surface if  $\mu_k = 0.250$ ?
- (A) 2.50 N  
(B) 24.5 N  
(C) 97.8 N  
(D) 392 N

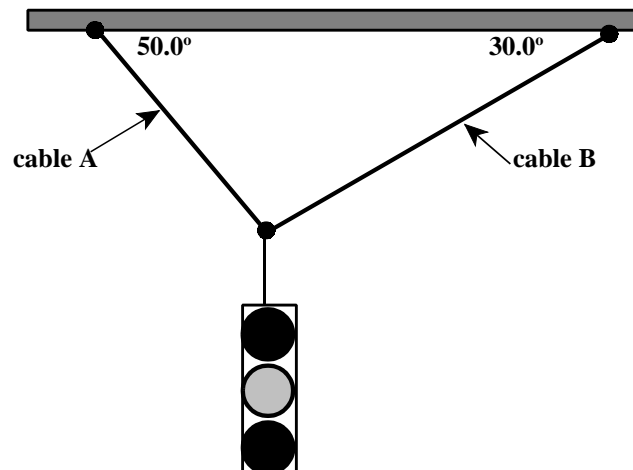
9. In the diagram below, two masses are connected by a light string over a frictionless, massless pulley. What coefficient of static friction is required to keep  $m_1$  from slipping?



- (A) 0.33  
 (B) 0.50  
 (C) 0.67  
 (D) 2.0
10. What is the magnitude of the acceleration in the system below if the incline is frictionless?



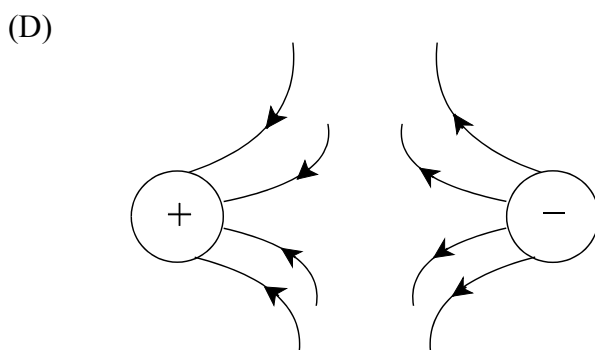
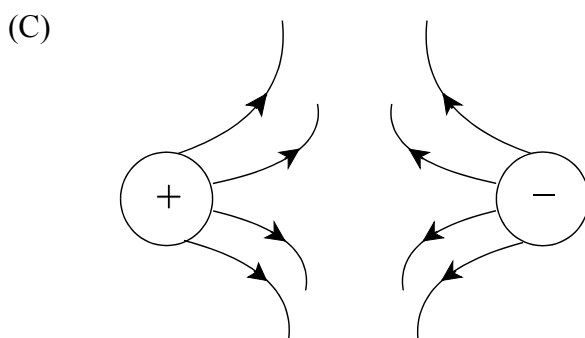
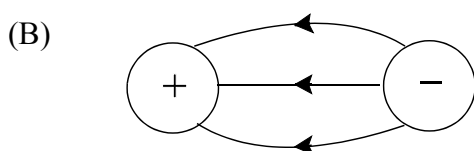
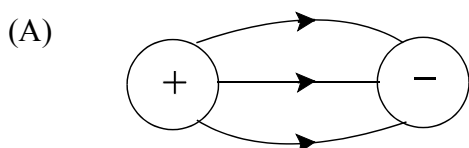
- (A)  $0.51 \text{ m/s}^2$   
 (B)  $1.5 \text{ m/s}^2$   
 (C)  $2.7 \text{ m/s}^2$   
 (D)  $3.3 \text{ m/s}^2$
11. In the diagram below, the tension in cable A is  $3.20 \times 10^2 \text{ N}$  and the tension in cable B is  $2.40 \times 10^2 \text{ N}$ . What is the mass of the traffic light?



- (A) 33.3 kg  
 (B) 37.3 kg  
 (C) 42.1 kg  
 (D) 46.2 kg

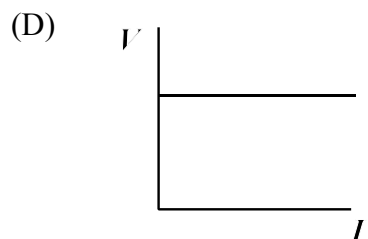
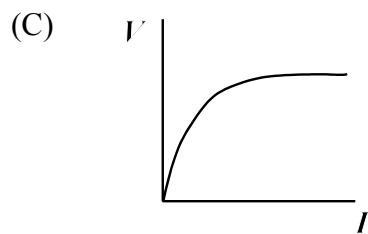
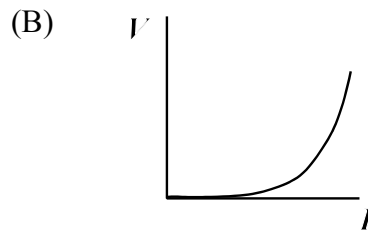
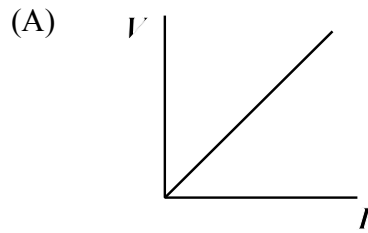
12. Which best describes the direction of the centripetal acceleration of an object in uniform circular motion?
- (A) in the direction of motion
  - (B) inward towards the centre of the circle
  - (C) opposite the direction of motion
  - (D) outward from the centre of the circle
13. What is the period of a satellite in a geosynchronous orbit above Earth?
- (A) 12 hours
  - (B) 24 hours
  - (C) 1 month
  - (D) 12 months
14. By what factor does the centripetal force change if a car goes around a curve at half its original speed?
- (A) decreases by a factor of 2
  - (B) decreases by a factor of 4
  - (C) increases by a factor of 2
  - (D) increases by a factor of 4
15. A car, travelling at 25.0 m/s, successfully moves around a banked, frictionless turn angled at  $7.32^\circ$ . What is the radius of this banked curve?
- (A) 19.9 m
  - (B) 37.7 m
  - (C) 63.8 m
  - (D) 496 m
16. A  $1.0 \times 10^3$  kg car rounds a 50.0 m horizontal curve with a speed of 15 m/s. If it is travelling with a speed such that it just barely avoids slipping on the road, what is the force of static friction between the tires and the road?
- (A)  $1.1 \times 10^2$  N
  - (B)  $3.0 \times 10^2$  N
  - (C)  $4.5 \times 10^3$  N
  - (D)  $9.8 \times 10^3$  N
17. What conditions are necessary for static equilibrium?
- (A)  $\vec{F}_{\text{net}} = 0, \vec{\tau}_{\text{net}} \neq 0$
  - (B)  $\vec{F}_{\text{net}} = 0, \vec{\tau}_{\text{net}} = 0$
  - (C)  $\vec{F}_{\text{net}} \neq 0, \vec{\tau}_{\text{net}} \neq 0$
  - (D)  $\vec{F}_{\text{net}} \neq 0, \vec{\tau}_{\text{net}} = 0$

18. What is the magnitude of the torque exerted on a door when a perpendicular force of 80.0 N is applied 1.5 m from the hinge?
- (A)  $5.3 \times 10^1 \text{ N}\cdot\text{m}$   
 (B)  $8.0 \times 10^1 \text{ N}\cdot\text{m}$   
 (C)  $1.2 \times 10^2 \text{ N}\cdot\text{m}$   
 (D)  $2.4 \times 10^2 \text{ N}\cdot\text{m}$
19. Two students are balanced on a uniform seesaw. Student A has a mass of 75.0 kg and student B has a mass of 85.0 kg. If student A is 1.5 m from the pivot point on one side of the seesaw, how far is student B from the pivot point?
- (A) 0.59 m  
 (B) 0.76 m  
 (C) 1.3 m  
 (D) 1.7 m
20. A  $1.0 \times 10^2 \text{ N}$  uniform beam, 10.0 m in length, is supported by a rope at each end. If a  $4.0 \times 10^2 \text{ N}$  person sits 2.0 m from the left end of the beam, what is the magnitude of the tension in the rope supporting the right end of the beam?
- (A)  $1.3 \times 10^2 \text{ N}$   
 (B)  $2.5 \times 10^2 \text{ N}$   
 (C)  $3.7 \times 10^2 \text{ N}$   
 (D)  $5.0 \times 10^2 \text{ N}$
21. Which diagram represents the electric field between a positive and negative charge?

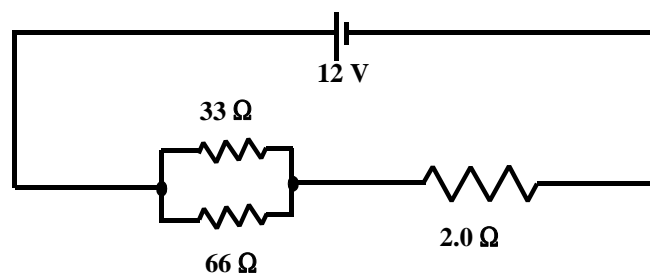


22. A positively charged rod is brought near one end of an uncharged metal bar. What will the end of the metal bar farthest from the charged rod become?
- (A) negative as electrons move away from this end
  - (B) negative as protons move to this end
  - (C) positive as electrons move away from this end
  - (D) positive as protons move to this end
23. When cell phone A calls cell phone B, 3 km away, the intensity is  $I$ . What is the intensity if cell phone A moves 6 km away from cell phone B?
- (A)  $\frac{1}{4} I$
  - (B)  $\frac{1}{2} I$
  - (C)  $2 I$
  - (D)  $4 I$
24. What is the electric field strength 45 cm from a  $5.0 \times 10^{-6} \text{ C}$  charged object?
- (A)  $1.0 \times 10^3 \text{ N/C}$
  - (B)  $1.0 \times 10^5 \text{ N/C}$
  - (C)  $2.2 \times 10^3 \text{ N/C}$
  - (D)  $2.2 \times 10^5 \text{ N/C}$
25. Which describes a voltaic cell?
- (A) consists of two identical metal plates connected by a conducting wire
  - (B) consists of two identical metal plates immersed in an electrolyte
  - (C) converts chemical energy into electrical energy
  - (D) converts electrical energy into chemical energy
26. A copper wire with a  $24 \Omega$  resistance is doubled in length. If the cross-sectional area remains constant, what is its new resistance?
- (A)  $12 \Omega$
  - (B)  $24 \Omega$
  - (C)  $48 \Omega$
  - (D)  $96 \Omega$
27. What is the total resistance when a  $12 \Omega$  and  $15 \Omega$  resistor are connected in parallel?
- (A)  $0.037 \Omega$
  - (B)  $0.15 \Omega$
  - (C)  $6.7 \Omega$
  - (D)  $27 \Omega$
28. A  $1.0 \times 10^3 \text{ W}$  bulb burns for 2.0 h. What is the total cost of the electricity used if the rate is eight cents per kilowatt hour?
- (A) \$0.04
  - (B) \$0.16
  - (C) \$0.25
  - (D) \$1.60

29. Which graph represents a linear circuit element?

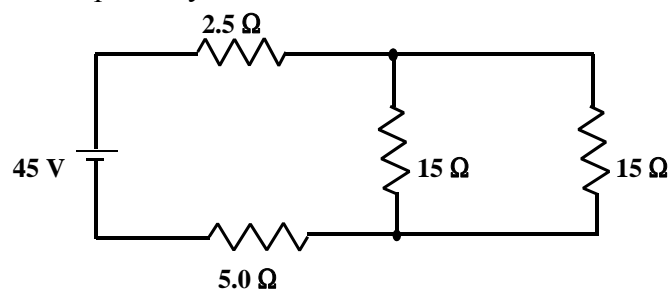


30. What is the current through the  $2.0\ \Omega$  resistor in the circuit below?



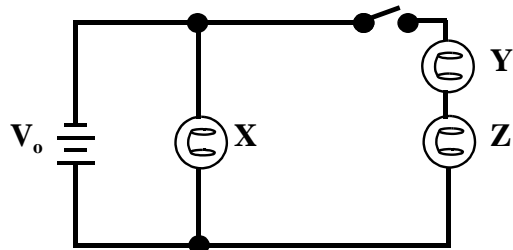
- (A) 0.12 A
- (B) 0.50 A
- (C) 2.0 A
- (D) 5.9 A

31. What is the power dissipated by the  $2.5\ \Omega$  resistor in the circuit below?



- (A) 0.28 W
- (B) 3.6 W
- (C) 23 W
- (D) 88 W

32. If  $2.00 \times 10^2$  mA of current flows through the filament of a light bulb, how many electrons would pass through the filament in 30.0 s?
- (A)  $2.67 \times 10^{-23}$   
 (B)  $2.67 \times 10^{-20}$   
 (C)  $3.75 \times 10^{19}$   
 (D)  $3.75 \times 10^{22}$
33. The switch in the circuit below is open. If the switch were closed in the same circuit, how would the brightness of the three bulbs (X, Y, Z) change, assuming all bulbs have equal resistance and are linear circuit elements?



	BULB X	BULB Y	BULB Z
(A)	brighter	dimmer	dimmer
(B)	dimmer	brighter	brighter
(C)	same	brighter	brighter
(D)	same	dimmer	dimmer

34. Which correctly shows the magnetic field around a current-carrying wire?

- (A) 
 Diagram (A) shows a central circle with an 'X' inside, representing a wire with current flowing into the page. Two concentric circles around it have arrows pointing clockwise, representing the magnetic field lines.
- (B) 
 Diagram (B) shows a central circle with a dot inside, representing a wire with current flowing out of the page. Two concentric circles around it have arrows pointing counter-clockwise, representing the magnetic field lines.
- (C) 
 Diagram (C) shows a central circle with an 'X' inside. Four arrows point towards the circle from the top, bottom, left, and right, representing the magnetic field lines.
- (D) 
 Diagram (D) shows a central circle with a dot inside. Four arrows point away from the circle towards the top, bottom, left, and right, representing the magnetic field lines.



35. Which is the most efficient way to transfer electricity from remote generating sites?

	potential	current
(A)	high	high
(B)	high	low
(C)	low	high
(D)	low	low

36. In which diagram would an external magnetic field,  $\vec{B}$ , cause the current-carrying wire to be deflected towards the left?

(A)

(B)

(C)

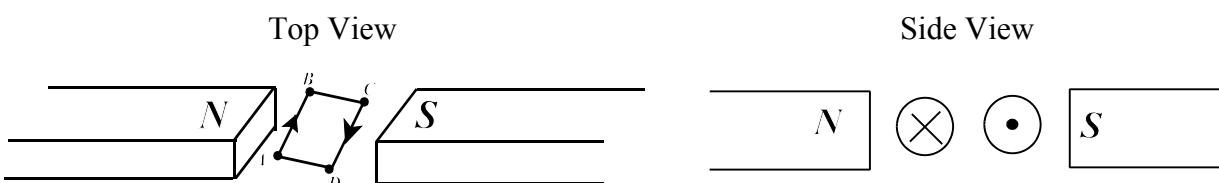
(D)

37. An ideal transformer has 500 turns in the primary coil. How many turns are in its secondary coil if there is 2.5 A in the primary coil and 12.5 A in the secondary coil?

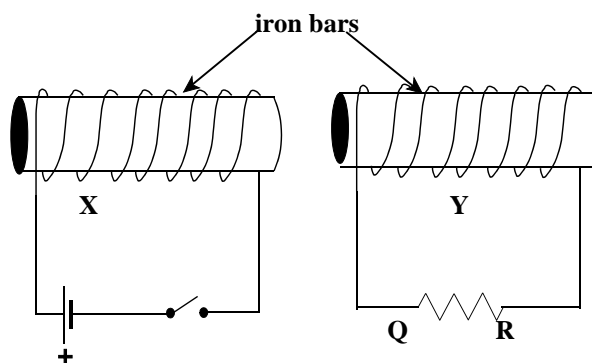
- (A) 16
- (B) 100
- (C) 625
- (D) 2500

38. An aircraft carries a static charge of 0.60 C. It travels at  $2.4 \times 10^4$  m/s, perpendicular to a  $1.5 \times 10^{-4}$  T magnetic field. What magnetic force is exerted on the aircraft?
- (A)  $2.2 \times 10^{-2}$  N  
 (B)  $6.0 \times 10^{-2}$  N  
 (C)  $5.4 \times 10^{-1}$  N  
 (D)  $9.6 \times 10^5$  N

39. Which describes the rotation of the armature in the magnetic field below?



- (A) AB deflects upwards  
 (B) BC deflects downwards  
 (C) CD deflects upwards  
 (D) DA deflects downwards
40. In the diagram below, when the switch is closed current flows through solenoid X. Which statement describes the current through the resistor?



- (A) A momentary current flows from Q to R.  
 (B) A momentary current flows from R to Q.  
 (C) A steady current flows from Q to R.  
 (D) A steady current flows from R to Q.
41. In the Sun, a series of nuclear reactions have the net effect of making one helium atom form four hydrogen atoms. Which process does this describe?
- (A) chain reaction  
 (B) fission  
 (C) fusion  
 (D) nuclear reactor
42. What is the energy of a photon of blue light if  $\lambda = 4.5 \times 10^2$  nm?
- (A)  $9.9 \times 10^{-49}$  J  
 (B)  $3.0 \times 10^{-40}$  J  
 (C)  $1.5 \times 10^{-25}$  J  
 (D)  $4.4 \times 10^{-19}$  J

43. If  $r_1$  is the smallest orbital radius around a single proton, what is  $r_6$ ?
- (A)  $2.5 r_1$   
 (B)  $6.0 r_1$   
 (C)  $12 r_1$   
 (D)  $36 r_1$
44. What speed must a 0.20 kg ball be moving if it has a de Broglie wavelength of  $2.2 \times 10^{-34}$  m?
- (A) 0.60 m/s  
 (B) 15 m/s  
 (C) 73 m/s  
 (D) 150 m/s
45. Light of a particular wavelength is incident on a metal surface. If electrons are emitted from this surface, what situation would result in more electrons per unit time with less kinetic energy per electron?

	Intensity	Wavelength
(A)	decrease	decrease
(B)	decrease	increase
(C)	increase	decrease
(D)	increase	increase

46. How many protons, neutrons, and nucleons are in the  $^{45}_{20}\text{Ca}$  nucleus?

	Number of protons	Number of neutrons	Number of nucleons
(A)	20	25	45
(B)	20	45	65
(C)	45	20	65
(D)	45	25	45

47. Which radioactive emission has the greatest penetrating power?
- (A) alpha  
 (B) beta negative  
 (C) beta positive  
 (D) gamma

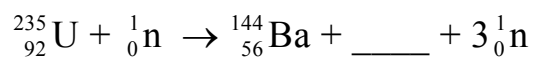
48. Which transmutation represents alpha decay?

- (A)  $^{15}_8\text{O} \rightarrow ^{15}_7\text{N} + ^0_{+1}\text{e}$   
 (B)  $^{230}_{90}\text{Th} \rightarrow ^{226}_{88}\text{Ra} + ^4_2\text{He}$   
 (C)  $^{227}_{89}\text{Ac} \rightarrow ^{227}_{90}\text{Th} + \alpha$   
 (D)  $^{14}_6\text{C} \rightarrow ^{14}_7\text{N} + ^0_{-1}\text{e}$

49. If element A has a half-life of 5 days, how many days will it take a  $1.0 \times 10^2$  mg sample to decay to 12.5 mg?

- (A) 3
- (B) 8
- (C) 15
- (D) 20

50. What is the missing product in the reaction below?



- (A)  ${}_{36}^{89}\text{Kr}$
- (B)  ${}_{36}^{91}\text{Kr}$
- (C)  ${}_{34}^{89}\text{Kr}$
- (D)  ${}_{34}^{91}\text{Kr}$

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

**Instructions:** Complete all questions in this section. Show calculations for numerical problems.

**Value**

2%      51.(a) If a rock is thrown horizontally from a 45.0 m high cliff with a velocity of 20.0 m/s, how far from the base of the cliff does the rock hit the ground?

(b) A 5.0 kg block is laid flat on an horizontal table ( $\mu_k = 0.10$ ). The block is pulled to the right with a force of 25 N, at  $15^\circ$  above the horizontal.

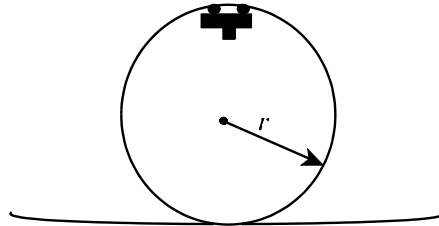
2%      (i) Sketch the free body diagram.

3%      (ii) What is the magnitude of the acceleration of the block?

**Value**

- 3% 51.(c) A car is moving around a horizontal curve with a radius of 50.0 m. If the coefficient of static friction is 0.75, what is the maximum speed for the car to travel safely around the curve without skidding?

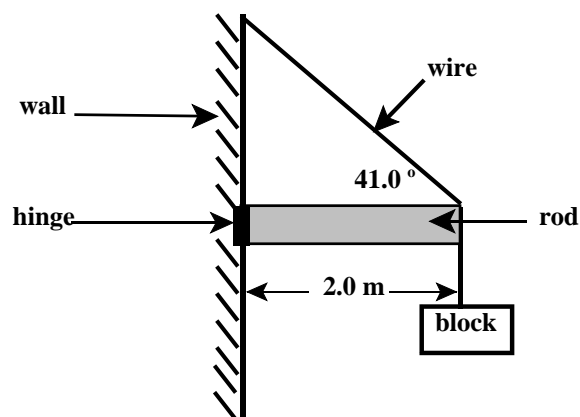
- 3% (d) The diagram below represents the loop of a roller coaster. If the radius of the loop is 12.0 m, what is the minimum speed, at the top of the loop, required to prevent passengers from falling out?



**Value**

2% 51.(e) What speed is required for an object to stay in an orbit two Earth radii above Earth's surface?

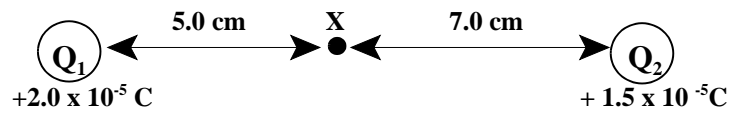
2% (f) (i) Sketch the free body diagram for the rod in the diagram below. Label all forces.



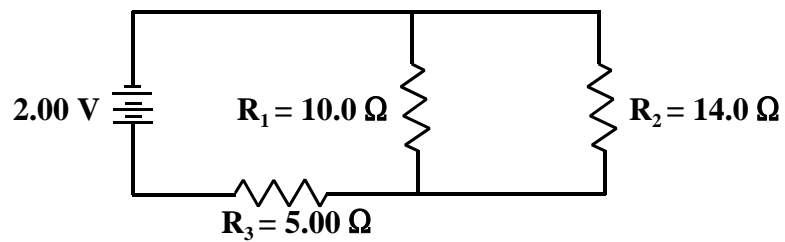
3% (ii) If the mass of the block is 5.0 kg and the rod is uniform with a mass of 0.40 kg, what is the magnitude of the tension in the wire?

**Value**

3% 52.(a) In the diagram below, what is the magnitude and direction of the net electric field resulting from the interaction of two fields ( $\vec{E}_1$  and  $\vec{E}_2$ ), at point X?



(b) Refer to the circuit diagram below to complete the questions that follow.



For this circuit diagram, calculate:

3% (i) total current:

2% (ii) voltage drop across  $R_2$ :

1% (iii) power dissipated by the parallel section:



**Value**

3%      52.(c) A 12 V battery is connected in a circuit that contains twenty-four  $40.0\ \Omega$  resistors in parallel. What is the current through each resistor?

2%      (d) There are two types of cell phones available for commercial use. The conventional model has a headset with an antenna. The belt chin model has a headset with earphones and an antennae on the belt. Which type of cell phone has the least health risks? Explain.

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3%      (e) An electron travels with a speed of  $2.00 \times 10^6$  m/s in a plane perpendicular to a  $1.00 \times 10^{-3}$  T magnetic field. What is the radius of the electron's path?

**Value**

3%      52.(f) Why is there an emf induced between the wingtips of an aircraft moving at 700.0 m/s in level flight directly above Earth’s magnetic North Pole? (Assume Earth’s magnetic field vector is pointing straight up as the plane flies over the North Pole.)

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53.(a) A  $1.00 \times 10^2$  W light bulb emits visible light at a wavelength of  $5.00 \times 10^2$  nm.

1%                      (i) How much energy does the emitted photons contain?

1%                      (ii) How much energy is emitted by the light bulb in 1.00 s?

1%                      (iii) How many photons are emitted in 1.00 s?

Value

2% 53.(b) A  $2.72 \times 10^{15}$  Hz photon acquires  $1.1 \times 10^{-18}$  J of kinetic energy. What is the work function of the metal?

2% (c) What is the frequency of photons that have a momentum of  $2.80 \times 10^{-27}$  kg · m/s?

3% (d) Radium-226 undergoes the following radioactive decay:  ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$   
How much energy is released given the masses below?

$$1\text{ }u = 1.66 \times 10^{-27}\text{ kg} = 931.5\text{ MeV}/c^2$$

isotope	mass (u)
${}^{226}_{88}\text{Ra}$	226.0244
${}^{222}_{86}\text{Rn}$	222.0164
${}^4_2\text{He}$	4.0026