PART I
Total Value: 50%

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

1. Which movement is an example of projectile motion?

(A) climbing a wall
(B) running around a track
✔ (C) throwing a ball off a cliff
(D) walking at a constant velocity

2. An egg is thrown in the air with a velocity of 15 m/s at 45° above the horizontal. What is its horizontal velocity and vertical acceleration when it reaches the maximum height?

	horizontal velocity (m/s)	vertical acceleration (m/s^2)
(A)	0	0
(B)	0	-9.8
(C)	11	0
✔ (D)	11	-9.8

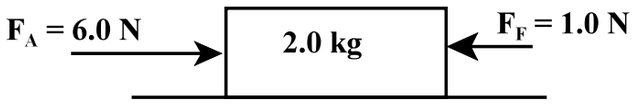
3. A projectile is launched at a 30.0° angle above the horizontal with a speed of 20.0 m/s. What is the vertical displacement after 3.0 s?

(A) - 74 m
✔ (B) - 14 m
(C) + 12 m
(D) + 31 m

4. If a coin is pushed horizontally from a 1.2 m high table and lands 0.68 m from the base, what was the speed at which it left the table?

✔ (A) 1.4 m/s
(B) 1.9 m/s
(C) 2.8 m/s
(D) 5.7 m/s

5. What is the magnitude of the acceleration for the object shown below?

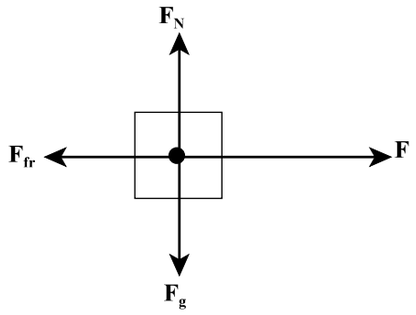


✔ (A) 2.5 m/s^2
(B) 3.0 m/s^2
(C) 9.8 m/s^2
(D) 12 m/s^2

6. A box is pulled on a smooth horizontal floor with a 1.00×10^2 N force, at 37.0° above the horizontal. If the mass of the box is 40.0 kg, what is the normal force?

(A) 292 N
(B) 312 N
✔ (C) 332 N
(D) 393 N

7. Which represents the coefficient of kinetic friction for the diagram below?



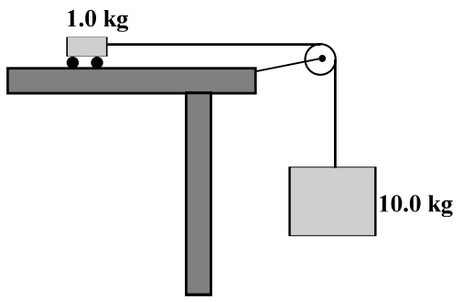
(A) $\frac{F}{F_g}$

(B) $\frac{F_{fr}}{F}$

(C) $\frac{F_N}{F_g}$

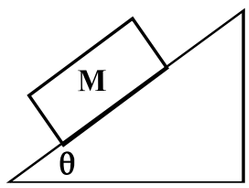
✔ (D) $\frac{F_{fr}}{F_N}$

8. The diagram below shows a 1.0 kg cart connected to a 10.0 kg mass. Assuming the surface is frictionless, what is the acceleration of the system if the net force is 98.0 N?



✔ (A) 8.9 m/s^2
(B) 9.8 m/s^2
(C) 11 m/s^2
(D) 98 m/s^2

9. In the diagram below, what causes acceleration down the incline? (Ignore friction)



(A) M cosθ
(B) Mg cosθ
✔ (C) Mg sinθ
(D) M sinθ

10. A block slides down an inclined plane at a constant velocity of 6.0 m/s. What is the coefficient of kinetic friction if the inclined plane makes a 25° angle with the horizontal?

(A) 0.37
(B) 0.42
✔ (C) 0.47
(D) 0.91

11. The tires on a moving bicycle make one complete rotation in 0.18 s. If the radius of the tires is 0.42 m, how fast is the bicycle travelling?

(A) 2.3 m/s
(B) 3.1 m/s
(C) 4.7 m/s
✔ (D) 15 m/s

12. What is the centripetal acceleration of a car as it travels at 36.0 m/s around a circle with radius 3.4×10^2 m?

(A) $0.11 m/s^2$
(B) $0.26 m/s^2$
✔ (C) $3.8 m/s^2$
(D) $9.4 m/s^2$

13. As the speed of a merry-go-round doubles, how does the magnitude of the centripetal force acting on a passenger change?

(A) halves
(B) doubles
(C) triples
✔ (D) quadruples

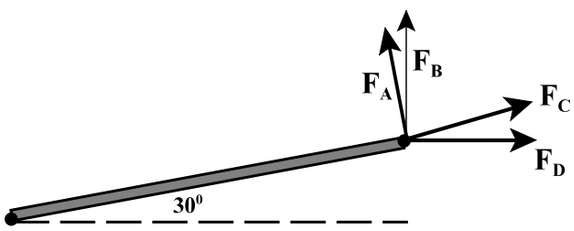
14. What is the speed of a satellite that orbits Earth 6.0×10^2 km above the surface?

✔ (A) 7.6×10^3 m/s
(B) 7.9×10^3 m/s
(C) 8.3×10^3 m/s
(D) 2.6×10^4 m/s

15. What is a single point at which the entire mass of a body is considered to be located?

✔ (A) center of mass
(B) center of rotation
(C) mass point
(D) moment of force

16. Which force in the diagram below would produce the most torque on the lever arm?

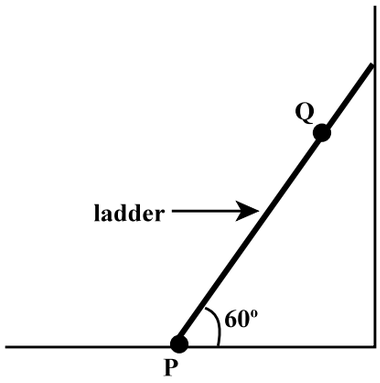


✔ (A) F_A
(B) F_B
(C) F_C
(D) F_D

17. A 4.0 N force is applied tangent to the outer edge of a bicycle wheel with radius 0.50 m. What is the torque applied to the wheel?

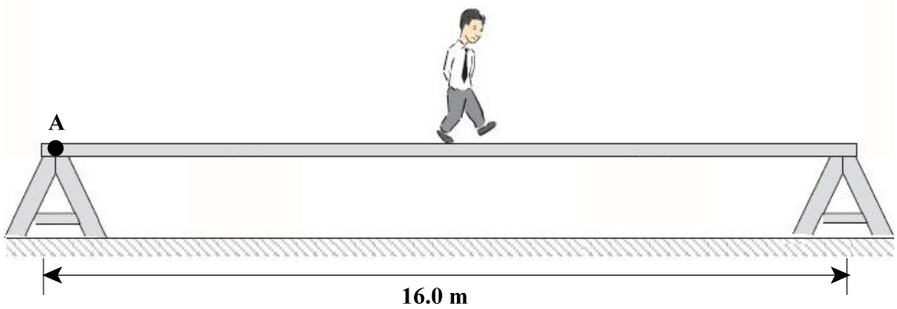
✔ (A) 2.0 N•m
(B) 3.5 N•m
(C) 4.5 N•m
(D) 8.0 N•m

18. In the diagram below a 65.0 kg person is 3.0 m up a ladder at Q. What is the magnitude and direction of the torque produced by the person about point P?



	magnitude	direction
(A)	1.7×10^3 N•m	clockwise
(B)	1.7×10^3 N•m	counterclockwise
✔ (C)	9.6×10^2 N•m	clockwise
(D)	9.6×10^2 N•m	counterclockwise

19. In the diagram below, a uniform 16.0 m long plank weighing 3.5×10^2 N rests on supports at each end of the plank. If a 8.5×10^2 N person stands in the middle of the plank, what is the magnitude of the normal force acting at A?



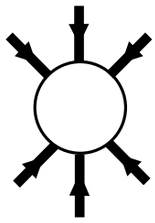
(A) 1.8×10^2 N
(B) 4.3×10^2 N
✔ (C) 6.0×10^2 N
(D) 1.2×10^3 N

20. A 4.00×10^3 N force is applied on one end of a 5.00 m lever. If an object on the other end of the lever is 1.00 m from the pivot point, what is the maximum weight that the object can be to balance the lever?

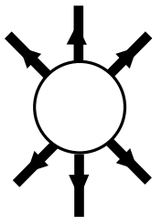
(A) 8.00×10^1 N
(B) 1.00×10^2 N
✔ (C) 1.60×10^4 N
(D) 2.00×10^4 N

21. Which represents the gravitational field around a spherical mass?

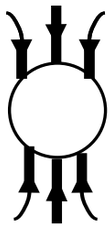
✔ (A)



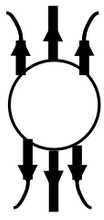
(B)



(C)



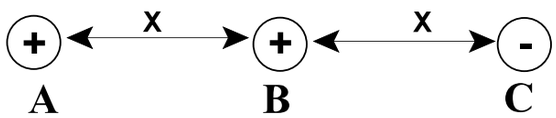
(D)



22. How many electrons are transferred when a 5.0 μC charged rod touches an electroscope?

(A) 5.0×10^6
✔ (B) 3.1×10^{13}
(C) 3.1×10^{19}
(D) 8.0×10^{25}

23. In the diagram below sphere A and B exert a 4.0 N force on each other. If all three spheres have equal charges, what is the net force on sphere C?



(A) 0 N
(B) 2.0 N
✔ (C) 5.0 N
(D) 8.0 N

24. The magnitude of the electrostatic force between two charges is F. If the distance (d) between the charges is increased to $\frac{3}{2}d$, what is the new force between the charges?

(A) F
(B) $\frac{2}{3}$ F
✔ (C) $\frac{4}{9}$ F
(D) $\frac{9}{4}$ F

25. If 4.8×10^{-17} J of work is required to move an electron between two points in an electric field, what is the electric potential difference between these points?

(A) 1.6×10^{-19} V
(B) 4.8×10^{-17} V
✔ (C) 3.0×10^{2} V
(D) 4.8×10^{2} V

26. Which scientist proposed that around any closed path the sum of the voltage rises is equal to the sum of the voltage drops?

(A) Coulomb
✔ (B) Kirchoff
(C) Ohm
(D) Volta

27. If four 20 Ω resistors are connected in parallel, what is the equivalent resistance?

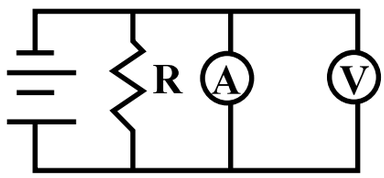
✔ (A) 5 Ω
(B) 10 Ω
(C) 20 Ω
(D) 80 Ω

28. How much current will a 1.2×10^{3} W hair dryer draw if it has a 10.0 Ω resistance?

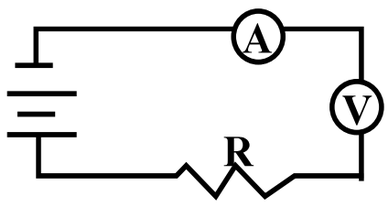
(A) 0.090 A
(B) 1.0 A
✔ (C) 11 A
(D) 12 A

29. Which circuit diagram below shows the proper connection of an ammeter and voltmeter to measure the current through and potential difference across a resistor?

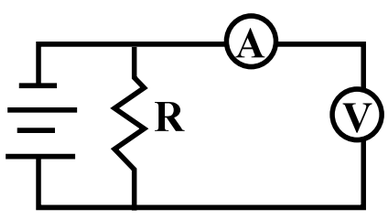
(A)



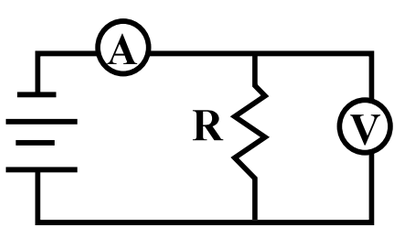
(B)



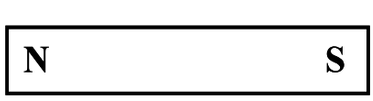
(C)



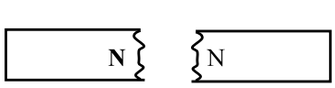
✔ (D)



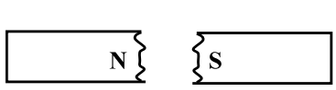
30. If the bar magnet below is broken, which represents the polarity of the region where the break occurs?



(A)

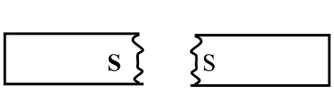


(B)



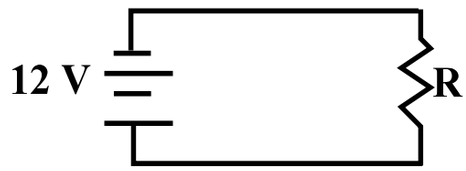
✔ (C)

(D)

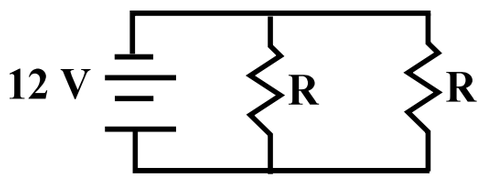


31. If identical resistors are connected across the same 12 V battery, which circuit uses the greatest power?

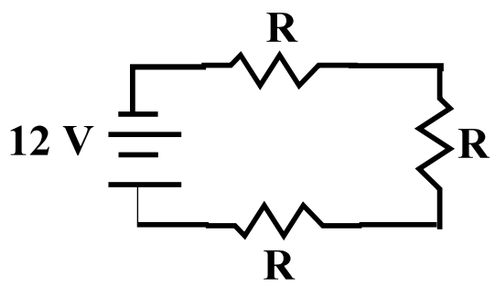
(A)



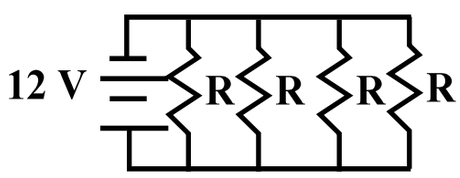
(B)



(C)



✔ (D)



32. How does a ferromagnetic substance act in the presence of a magnetic field?

✔ (A) strongly attracted
(B) strongly repelled
(C) weakly attracted
(D) weakly repelled

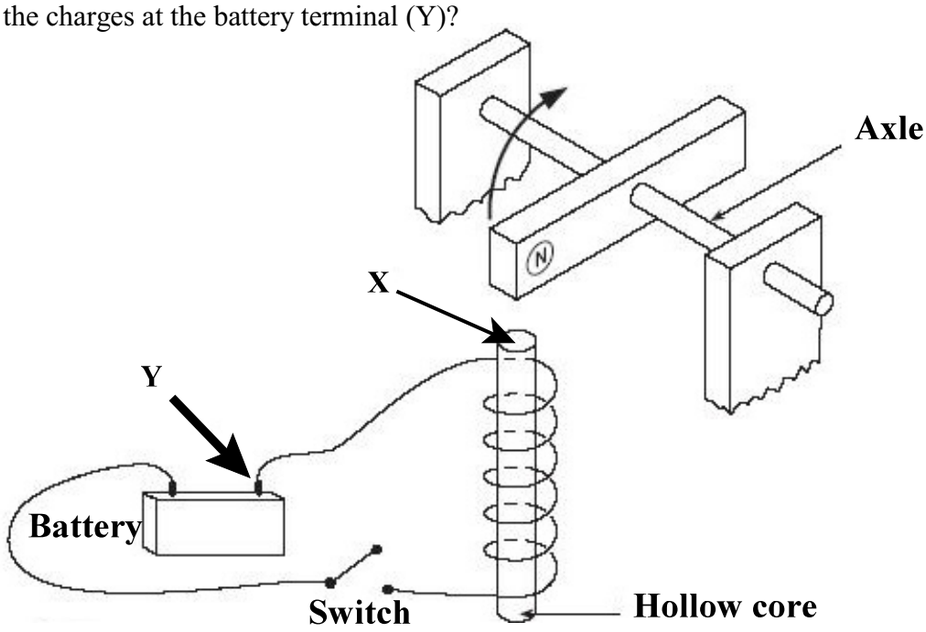
33. By what factor would the strength of the signal from a cell phone decrease if the cell phone was initially located 2.0 km from a transmitting tower and was moved to a point 10.0 km from the tower?

(A) 5
(B) 8
(C) 20
✔ (D) 25

34. If a 6.0 Ω and a 12 Ω resistor are connected in parallel to a 36 V battery, what power is dissipated by the 6.0 Ω resistor?

(A) 24 W
(B) 48 W
✔ (C) 2.2×10^2 W
(D) 4.9×10^2 W

35. In the diagram below, a permanent magnet is balanced above a coil of wire. When the switch is closed, the magnet is deflected upward. What is the magnetic polarity at the hollow core (X) and the charges at the battery terminal (Y)?

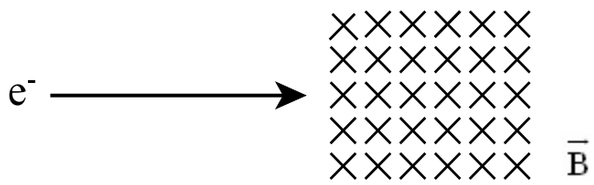


		X	Y
✔	(A)	north	negative
	(B)	north	positive
	(C)	south	negative
	(D)	south	positive

36. A step-down transformer is needed to reduce a primary voltage of 120 V to 6.0 V. If the primary coil has 60 turns, how many turns are required on the secondary coil?

✔ (A) 3
(B) 20
(C) 720
(D) 1200

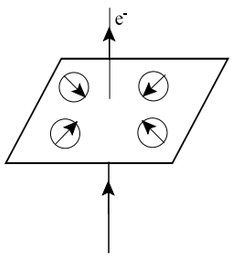
37. In which direction will the electron be deflected in the diagram below?



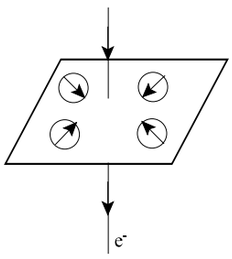
✔ (A) down toward the bottom of page
(B) into the page
(C) out of the page
(D) up toward the top of page

38. Which shows the direction compass needles are deflected when placed near a current-carrying wire?

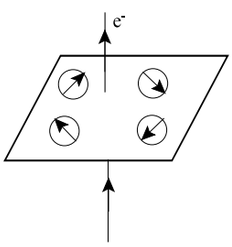
(A)



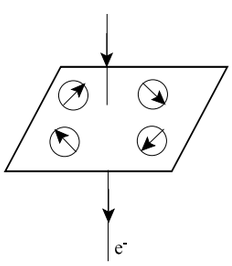
(B)



✔ (C)

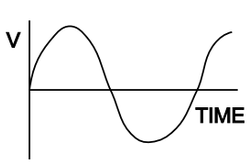


(D)

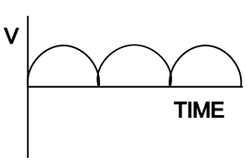


39. Which graph represents the voltage output from a single coil D.C. generator?

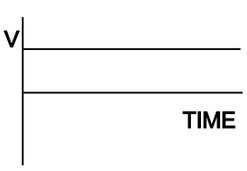
(A)



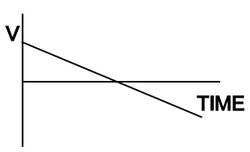
✔ (B)



(C)

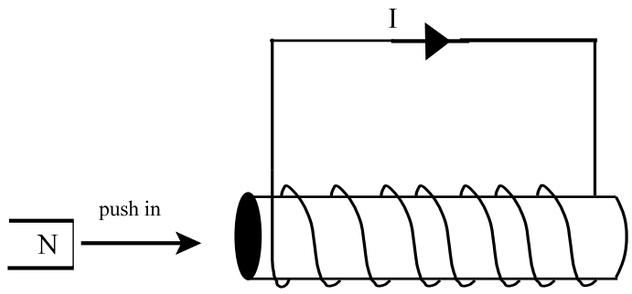


(D)

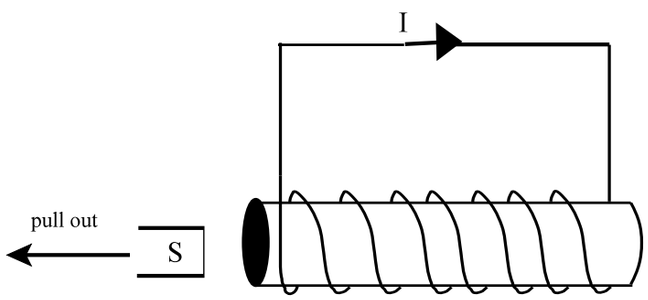


40. Which diagram shows the direction of the induced current?

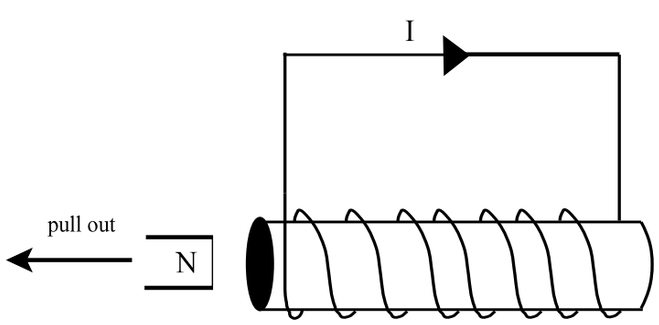
(A)



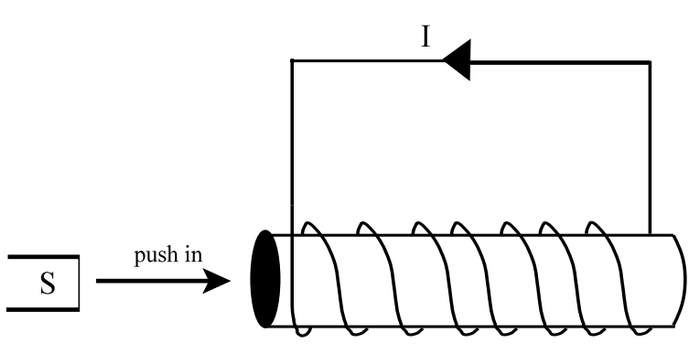
(B)



✔ (C)



(D)



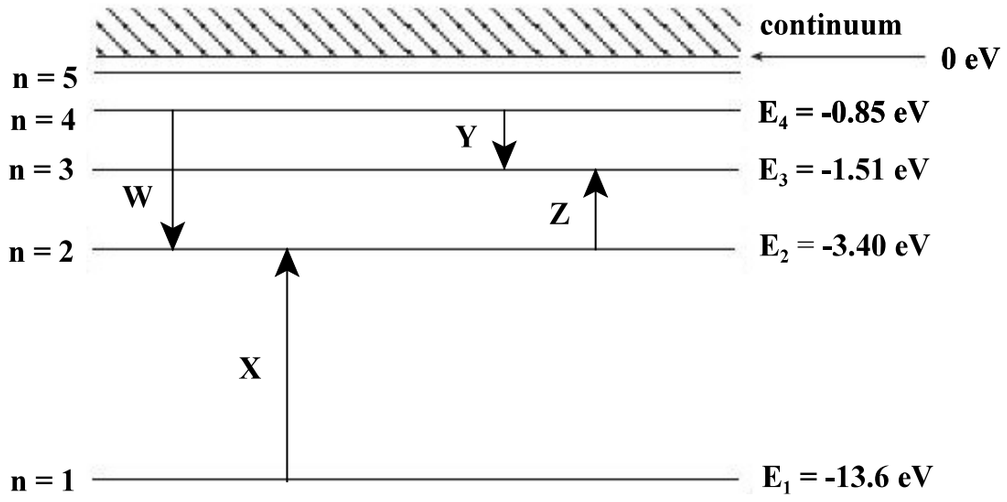
41. How much energy is carried by a photon with a 661 nm wavelength?

(A) 1.46×10^{-48} J
(B) 4.38×10^{-40} J
(C) 6.63×10^{-34} J
✔ (D) 3.01×10^{-19} J

42. When light of frequency 8.6×10^{14} Hz is incident on a metal surface, the maximum kinetic energy of the photoelectrons is 0.500 eV. What is the work function of the metal?

(A) 0.50 eV
✔ (B) 3.1 eV
(C) 3.5 eV
(D) 4.1 eV

43. The diagram below shows the energy level diagram of a hydrogen atom. The arrows (W, X, Y, Z) indicate transitions of electrons in the atom. Which transition would cause the emission of a photon with the shortest wavelength?



✔ (A) W
(B) X
(C) Y
(D) Z

44. What did Compton discover after bombarding electrons with high energy photons?

✔ (A) A photon's momentum depends on its wavelength.
(B) A photon with a short wavelength can be ejected.
(C) Electrons and positrons come in pairs.
(D) Electrons can be split into smaller particles.

45. How many protons, neutrons, and electrons are in a $^{93}_{41}\mathrm{Nb}$ nucleus?

	protons	neutrons	electrons
(A)	41	41	52
✔ (B)	41	52	41
(C)	93	52	93
(D)	93	93	52

46. What is another term for an α particle?

✔ (A) helium nucleus
(B) helium photon
(C) neutron
(D) positron

47. Which represents the β^- decay of thorium 234?

(A) $^{234}_{90}\mathrm{Th} \rightarrow {}^{233}_{89}\mathrm{Ac} + \beta^-$

(B) $^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{89}\mathrm{Ac} + \beta^-$

(C) $^{234}_{90}\mathrm{Th} \rightarrow {}^{233}_{91}\mathrm{Pa} + \beta^-$

✔ (D) $^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + \beta^-$

48. A Geiger counter detects 240 decays per minute from a pure radioactive sample. If the rate reduces to 15 decays per minute after 12 days, what is the half life of the sample?

✔ (A) 3 days
(B) 4 days
(C) 8 days
(D) 15 days

49. Which best refers to critical mass?

✔ (A) The minimum mass of nuclear material required for an uncontrolled chain reaction.
(B) The minimum mass required to make a reactor economically viable.
(C) The total mass of uranium and plutonium in a reactor.
(D) The total mass on the verge of becoming radioactive.

50. If the mass of the products in a fission reaction is 3.2×10^{-28} kg less than the reactants, how much energy is released in the reaction?

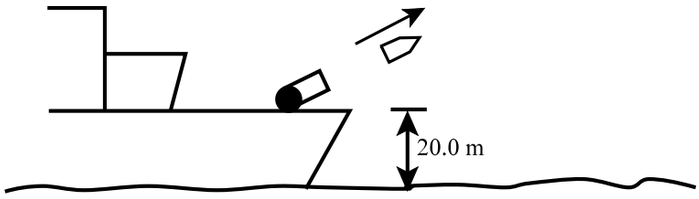
(A) 3.6×10^{-45} J
(B) 1.1×10^{-38} J
(C) 9.6×10^{-20} J
✔ (D) 2.9×10^{-11} J

PART II
Total Value: 50%

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

Value

4% 51.(a) In the diagram below, a shell is shot from a cannon, with an initial speed of 4.4×10^2 m/s, at 30.0° from the deck of a ship. If the ship is at rest and the shell is launched 20.0 m above sea level, how far will the shell travel horizontally from its original position into the sea? Assume friction is negligible.



$$\cos\theta = \frac{\vec{v}_{1x}}{\vec{v}}$$

V_{1x} = cos 30⁰ x 4.4 x10² m/s
= 3.8 x 10² m/s

$$\sin\theta = \frac{\vec{v}_{1y}}{\vec{v}}$$

V_{1y} = sin 30⁰ x 4.4 x 10² m/s
= 2.20 x 10² m/s

$$\vec{d}_y = \vec{V}_{1y}t + 1/2\vec{a}_y t^2$$

$$-20 = 220t - 1/2(9.80)t^2$$

$$0 = -4.9t^2 + 220t + 20$$

$$t = \frac{-220 \pm \sqrt{(220)^2 - 4(-4.90)(20)}}{2(-4.90)}$$

$$t = \frac{-220 \pm 220.9}{-9.8} = 45s \text{ or } -0.09s$$

$$d_x = V_x \text{ x } t$$

$$d_x = 3.8x10^2 m/s \text{ x } 45s = 1.7x10^4 m$$

2% (b) What happens to the motion of an object undergoing uniform circular motion if the net force on the object becomes zero?

An object undergoing uniform circular motion has an Unbalanced force that causes it to undergo centripetal acceleration and maintain it's orbital motion. Once this net force is removed, (Fnet =0), the object will no longer maintain orbital motion but will move in a straight path along a line that is tangent to it's original circular path at the point of it's release.

It will be moving with a uniform velocity.

Value

3% 51.(c) What is the maximum speed a car can travel around a curve on a flat road if the radius of the curve is 1.40×10^2 m and the tires and road have a coefficient of static friction of 0.35?

$$F_c = F_{fr}$$

$$\frac{mv^2}{r} = \mu s.mg$$

$$v^2 = \mu s.r.g$$

$$v = \sqrt{(0.35)(1.40x10^2 m)(9.80 m/s^2)} = 22 m/s$$

3% (d) A ball is thrown upward from a point 1.1 m above the ground at an initial velocity of 2.8 m/s and at a 78° angle to the horizontal. How high will the ball rise with respect to the ground?

$$\sin\theta = \frac{\bar{v}_{1y}}{\bar{v}}$$

$$\bar{v}_{2y}{}^2 = \bar{v}_{1y}{}^2 + 2\bar{a}_y\bar{d}_y$$

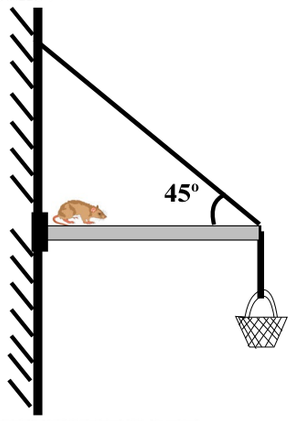
0^2 = (2.7m/s) + 2(-9.80m/s^2)(dy)

V1y = sin78^0 x 2.8 m/s
= 2.7 m/s

dy = 0.37 m

Height with respect to ground=0.37 m +1.1m =1.5 m

4% (e) In the diagram below, a 1.5 kg rat walks on a 2.0 kg uniform beam that is 2.2 m long. It wants to reach a 1.3 kg food basket hanging at the end. A cord that can withstand 45.5 N is used to support the beam at the end. What is the maximum distance the rat can walk on the beam before the cord breaks?



$$\tau_{cw} = \tau_{ccw}$$

$$\tau_{chord} = \tau_{rat} + \tau_{beam} + \tau_{basket}$$

$$rF\sin\theta = rFg\sin\theta + rFg\sin\theta + rFg\sin\theta$$

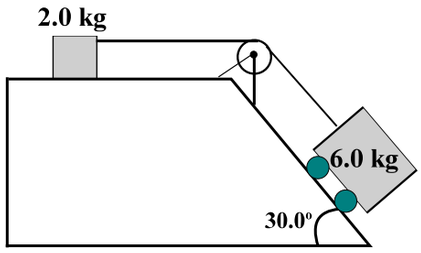
$$(2.2m)(45.5N)(\sin 45^0) = r(14.7N) + (1.1m)(19.6N) + (2.2m)(12.7N)$$

$$71N.m = r(14.7N) + 49.59N.m$$

$$r = 1.46m$$

Value

51.(f) When a 6.0 kg frictionless cart is attached to the 2.0 kg box shown below, it slides forward. The coefficient of kinetic friction between the horizontal surface and the box is 0.10.



2% (i) What is the acceleration of the system?

$F_{fr} = \mu k.mg$

$F_{\parallel} = mg\sin\theta$

$F_{net} = F_{\parallel} - F_{fr}$

$= mg.\sin\theta - \mu k.mg$

$\bar{a} = \dfrac{\bar{F}_{net}}{m}$

$= \dfrac{(6kg)(9.80N/kg)(\sin 30^0)-(0.10)(2kg)(9.80N/kg)}{(6\text{ kg} + 2.0\text{ kg})}$

= 3.4 m/s²

2% (ii) What is the magnitude of the tension in the rope?

using 2.0kg box:

$Fnet = ma$

$T - \mu kmg = ma$

$T = \mu kmg + ma$

$= (0.10)(2)(9.8) + (2)(3.4) = 8.8N$

52.(a) Two identically charged objects are placed 2.0 cm apart. The force of repulsion between them is 2.8×10^{-2} N.

2% (i) Determine the magnitude of the charge on each object.

$\bar{F} = \dfrac{kq_1q_2}{r^2}$

$2.8 \times 10^{-2}\text{N} = \dfrac{(9.0\times10^9\text{N.m}^2/\text{C}^2)(Q1)(Q2)}{(0.02\text{m})^2}$

$1.1 \times 10^{-5}\ \text{N.m}^2 = 9.0\times10^9\text{N.m}^2/\text{C}^2 \times Q^2$

$Q = \sqrt{1.2\times10^{-15}\,C} = 3.5 \times 10^{-8}$ C

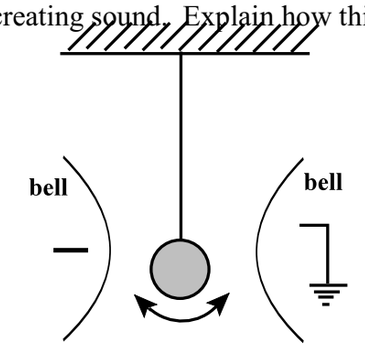
1% (ii) The charge on one object is doubled and the charge on the other is tripled. How will this change affect the magnitude of the electrical force between them?

$\bar{F} = \dfrac{kq_1q_2}{r^2} = \dfrac{k(2q_1)(3q_2)}{r^2} = \dfrac{6xkxq_1q_2}{r^2} = 6xFe$

Electric force will increase 6x

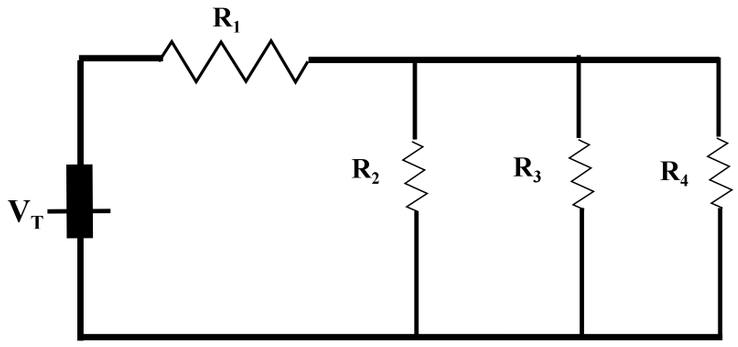
Value

3% 52.(b) In the diagram below, a metal ball on an insulated thread moves back and forth between two bells, creating sound. Explain how this occurs.



The neutral metal ball is attracted to the negatively charged bell. The excess electrons on the negatively charged bell are then transferred by conduction onto the metal ball causing the ball to become net negatively charged. The negatively charged ball is then repelled from the bell and collides with the grounded bell to the right. The excess electrons on the negative ball are then transferred onto the grounded bell and then through the ground wire, leaving the ball neutral which will then be attracted to the neg. bell again

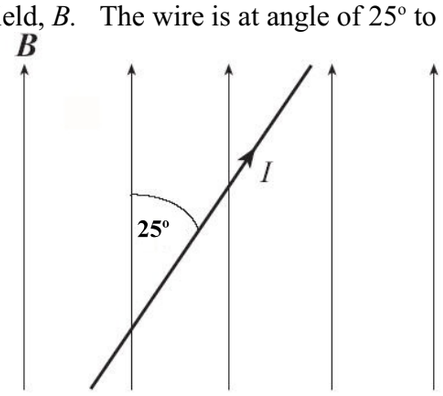
5% (c) Complete the table below for the given circuit. Show all workings in the space provided below the circuit diagram.



	Resistor 1	Resistor 2	Resistor 3	Resistor 4	Total
Voltage (V)	**16**	**8**	**8**	**8**	**24**
Current (A)	**4**	**3**	**0.5**	**0.5**	**4**
Resistance (Ω)	**4**	**2.7**	**16**	**16**	**6**

Value

2% 52.(d) The diagram below shows a wire of infinite length carrying a 15 A current in a uniform 0.55 T magnetic field, *B*. The wire is at angle of 25° to the magnetic field lines.

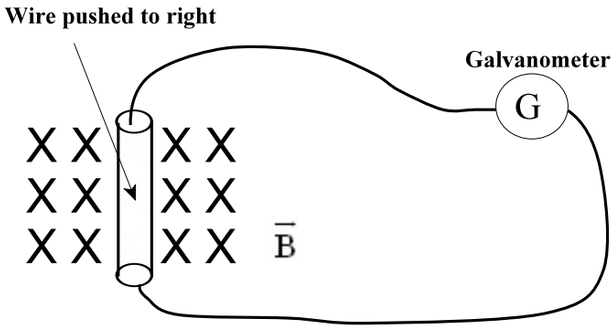


What is the magnitude and direction of the magnetic force acting on a 1.0 m section of the wire?

$F = B\ I\ L \sin\theta$
$= 0.55\ T \times 15\ A \times 1.0\ m \times \sin 25^0$
$= 3.5\ N$[into the page at 25^0]

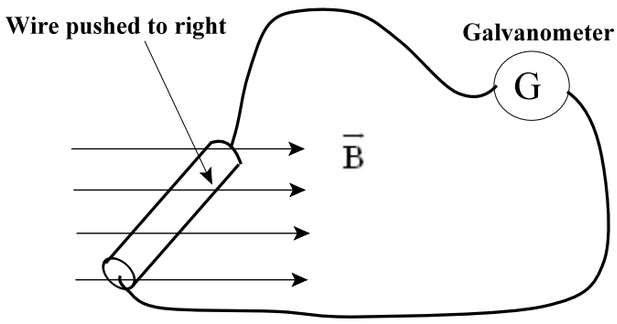
(e) In the two situations below, a wire is pulled through a region with a given magnetic field as shown. Determine whether a current will be induced in the wire and show its direction.

1% (i)



The electrons in the atoms of the wire are being physically moved perpendicular to the magnetic field lines that are point into the page. Therefore, a current will be induced and it will travel counterclockwise through the loop.

1% (ii)



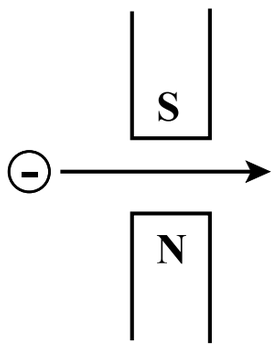
Since the conductor is moving parallel to the magnetic field lines, no current will be induced in the closed circuit.

Value

52.(f) A charged particle is shot through a magnetic field as shown in each case below. Determine whether it will be deflected by the magnetic field and show the direction of the deflection.

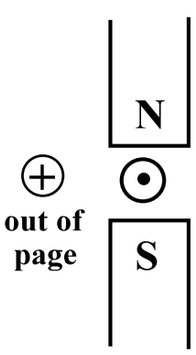
1% (i) negative particle

Using LHR #3, it can be determined that the negative particle will be deflected into the page.



1% (ii) positive particle

Using RHR, particle is deflected to right



3% (g) What is the magnitude of a uniform magnetic field that causes an electron to move in a circular arc of radius 5.00×10^{-2} m, if the speed of the electron is 9.50×10^{6} m/s?

$$F_c = F_e$$

$$\frac{mv^2}{r} = qvB\sin 90^0$$

$$\frac{mv}{r} = qB$$

$$B = \frac{mv}{qr} = \frac{(9.11x10^{-31}kg)(9.50x10^{6}m/s)}{(1.60x10^{-19}C)(5.00x10^{-2}m)} = 1.08x10^{-3}T$$

Value

2% 53.(a) If the work function of silver is 3.83 eV, what is the longest wavelength of sunlight that can eject an electron from a silver surface?

Wo = 3.83 eV x 1.609 x 10^{-19}J/eV = 6.16 x 10^{-19} J

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{(6.626x10^{-34} J.s)(3.00x10^{8} m/s)}{(6.16x10^{-19} J)} = 3.0x10^{-7} m$$

2% (b) If element X has a half-life of 6 days, how many days will it take a 1.3 × 10^2 mg sample to decay to 15 mg?

$$A = A_0(1/2)^{\frac{t}{T1/2}}$$

$$A = A_0(1/2)^{\frac{t}{T1/2}}$$

$$15mg = 1.3x10^{2}(0.5)\frac{t}{6}$$

$$\log\frac{15}{1.3x10^{2}} = \log(0.5)\frac{t}{6}$$

$$t = 6x\frac{\log 0.12}{\log 0.5} = 18.3days$$

3% (c) How much energy is released during the fusion of one atom of $^{2}_{1}\mathrm{H}$ and one atom of $^{3}_{1}\mathrm{H}$?

$$^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}n$$

Isotope	Mass (kg)
$^{2}_{1}\mathrm{H}$	3.3444 ×10^{-27}
$^{3}_{1}\mathrm{H}$	5.0082 × 10^{-27}
$^{4}_{2}\mathrm{He}$	6.6463 × 10^{-27}
$^{1}_{0}n$	1.6749 × 10^{-27}

Mass of reactants=3.3444x10^{-27}kg +5.0082x10^{-27}kg =8.3526 x 10^{-27} kg

Mass of products = 6.6463x10^{-27}kg +1.6749x10^{-27}kg =8.3212 x 10^{-27} kg

Mass difference= Mass of Reactants - Mass of Products
= 8.3526x10^{-27}kg - 8.3212x10^{-27}kg= 3.14 x10^{-29} kg

E = mc^2
= (3.14 x10^{-29} kg)(3.00 x10^{8}m/s)^2 = 2.83 x 10^{-12} J

Value

3% 53.(d) A hydrogen atom in the first excited state (n =2) absorbs a photon and moves to the second excited state (n =3). What is the frequency of the absorbed photon?

$$\mathbf{E_{n=2} = \frac{-2.18 \times 10^{-18} J}{(2)^2} = -5.45 \times 10^{-19} J}$$

$$\mathbf{E_{n=3} = \frac{-2.18 \times 10^{-18} J}{(3)^2} = -2.42 \times 10^{-19} J}$$

$$\mathbf{E_{\lambda} = E_2 - E_3 = -5.45 \times 10^{-19} J - -2.42 \times 10^{-19} J = -3.03 \times 10^{-19} J}$$

$$\mathbf{f = \frac{E}{h} = \frac{3.03 \times 10^{-19} J}{6.626 \times 10^{-34} J.s} = 4.57 \times 10^{14} Hz}$$