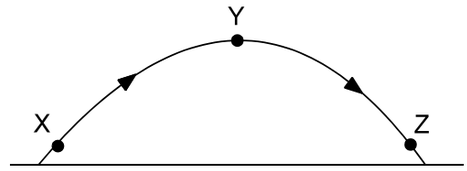
PART I
Total Value: 50%

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

1. What is the acceleration of the projectile at each point in the diagram below?



	Acceleration (m/s^2)		
	X	Y	Z
(A)	-9.8	-9.8	-9.8
(B)	-9.8	0	9.8
(C)	9.8	9.8	-9.8
(D)	9.8	0	-9.8

2. If a projectile is launched from ground level with an initial velocity of 65 m/s at 30.0° above the horizontal, what is its total time in the air?

(A) 3.3 s
(B) 6.6 s
(C) 12 s
(D) 13 s

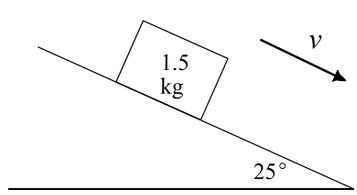
3. An object is projected horizontally from a 0.95 m high table at a velocity of 12 m/s. How far from the base of the table will the object hit the floor?

(A) 2.3 m
(B) 5.3 m
(C) 11 m
(D) 27 m

4. Two arrows are launched at the same time with the same initial velocity. Arrow X is fired at an angle of 60° to the horizontal, and arrow Y is fired at an angle of 45° to the horizontal. Which best describes the motion of arrow X compared to the motion of arrow Y?

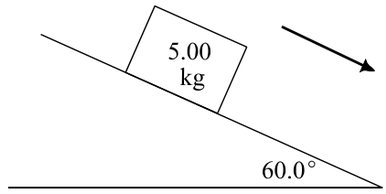
(A) Arrow X has a longer flight time and longer horizontal range.
(B) Arrow X has a longer flight time and shorter horizontal range.
(C) Arrow X has a shorter flight time and longer horizontal range.
(D) Arrow X has a shorter flight time and shorter horizontal range.

5. A 1.5 kg block slides down an incline at a constant speed as shown. What is the net force acting on this block?



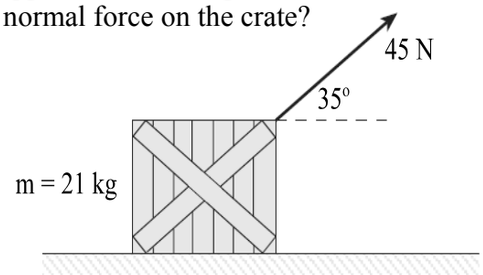
(A) 0 N
(B) 6.2 N
(C) 13 N
(D) 15 N

6. If a 5.00 kg box slides down a ramp inclined at 60.0° above the horizontal, what is the normal force exerted on the box?



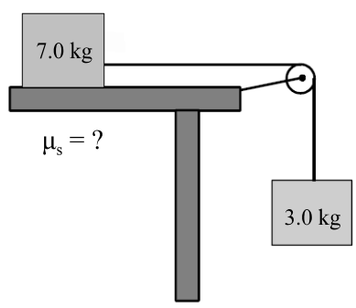
(A) 2.50 N
(B) 24.5 N
(C) 42.4 N
(D) 49.0 N

7. If a force of 45 N is applied at a 35° angle above the horizontal to pull a 21 kg crate forward, what is the normal force on the crate?



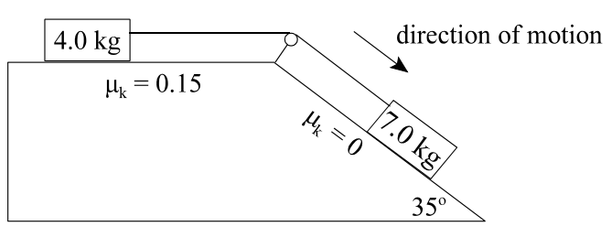
(A) 170 N
(B) 180 N
(C) 210 N
(D) 230 N

8. If the system below is at rest, what is the coefficient of static friction?



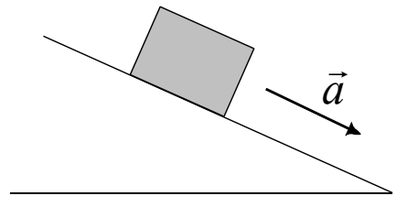
(A) 0
(B) 0.30
(C) 0.43
(D) 0.70

9. The diagram below shows two blocks connected by a massless string over a frictionless pulley. If the blocks accelerate at 3.0 m/s^2 in the direction shown, what is the tension in the connecting string?

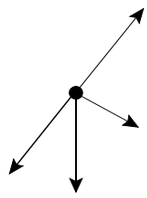


(A) 6 N
(B) 12 N
(C) 18 N
(D) 49 N

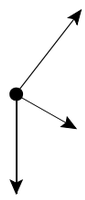
10. The diagram below shows an object sliding down a frictionless inclined plane at a constant acceleration. Which free body diagram best represents this object?



(A)



(B)



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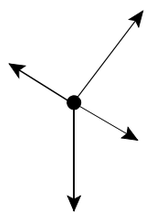

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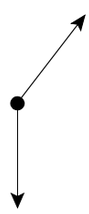
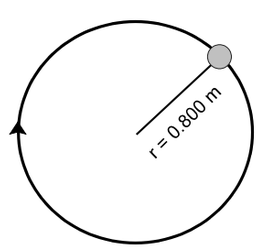


11. Which is the centripetal force for a car in a frictionless banked curve?

(A) horizontal component of the normal force
(B) horizontal component of the weight
(C) vertical component of the normal force
(D) vertical component of the weight

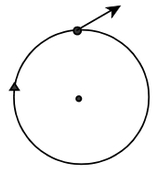
12. The diagram below shows an object, attached to a string, moving at a constant speed of 4.00 m/s in a horizontal circle. What is the magnitude of the centripetal acceleration of the object?



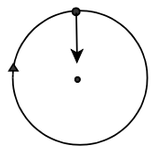
(A) 0.0500 m/s^2
(B) 2.00 m/s^2
(C) 5.00 m/s^2
(D) 20.0 m/s^2

13. Which shows the velocity vector for an object in uniform circular motion?

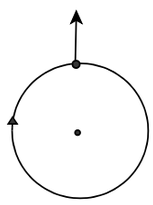
(A)



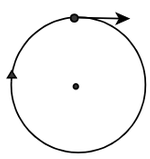
(B)



(C)

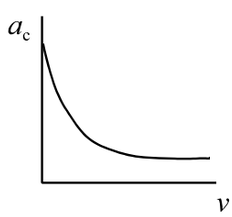


(D)

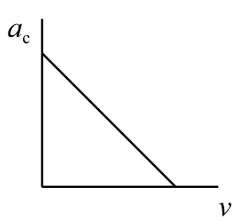


14. In a series of test runs, a car travels around the same circular track at different velocities. Which graph shows the relationship between its centripetal acceleration, a_c, and its velocity v?

(A)

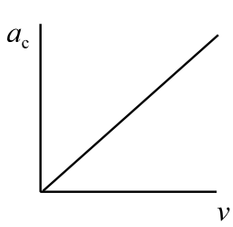


(B)

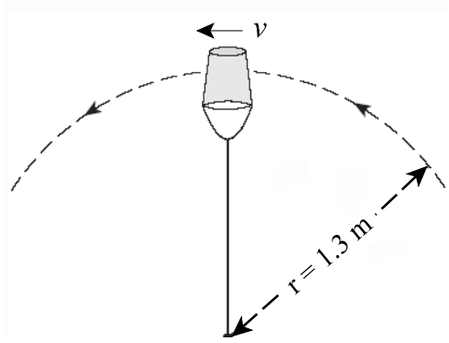


(C)

(D)



15. The diagram below shows a pail of water being swung in a vertical circle of radius 1.3 m. What is the minimum speed, v, at the top of the circle that will keep the water from spilling?



(A) 3.6 m/s
(B) 7.5 m/s
(C) 9.8 m/s
(D) 13 m/s

16. At which point on a uniform object can the force of gravity be considered to act?

(A) centre of mass
(B) centre of rotation
(C) moment of force
(D) moment of torque

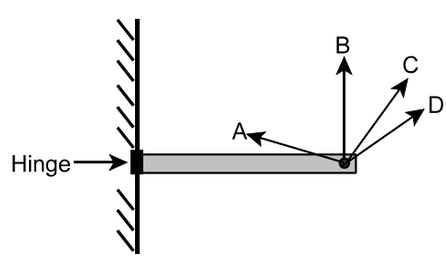
17. A perpendicular force of 14 N is applied at 2.0 m from the pivot point of a seesaw. What is the magnitude of the torque about the pivot?

(A) 0.14 N·m
(B) 7.0 N·m
(C) 12 N·m
(D) 28 N·m

18. Which condition will produce rotational equilibrium?

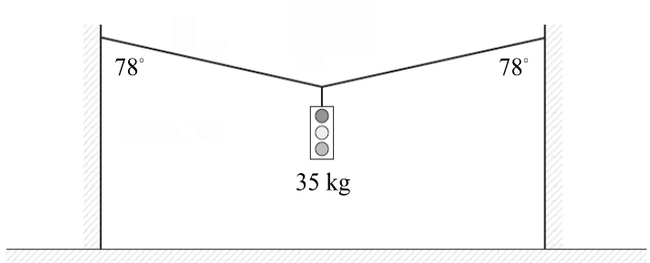
(A) $\vec{F}_{net} = 0$
(B) $\vec{F}_x = 0$
(C) $\vec{\tau}_{net} = 0$
(D) $\vec{\tau}_x = 0$

19. The diagram below shows a force applied on a beam in different directions. In which direction will the force produce the smallest torque about the hinge?



(A) A
(B) B
(C) C
(D) D

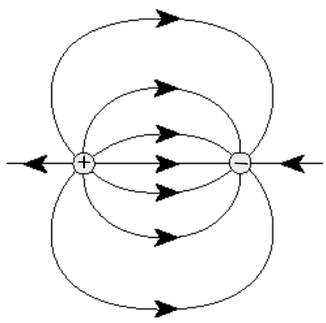
20. If a traffic light is suspended by two wires as shown below, what is the tension in each wire?



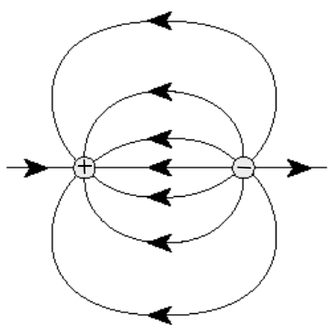
(A) 180 N
(B) 340 N
(C) 820 N
(D) 1 600 N

21. Which shows the electric field between two equal but opposite charges?

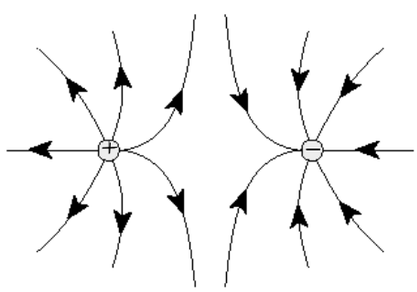
(A)



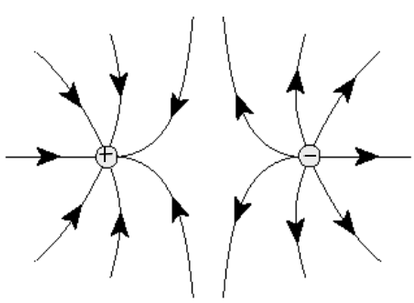
(B)



(C)



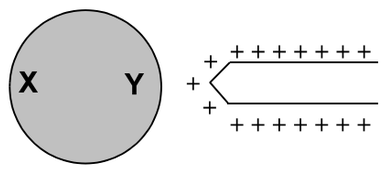
(D)



22. Which describes a neutral electroscope after it is briefly touched with a positively charged rod?

(A) top of electroscope negative, bottom of electroscope negative
(B) top of electroscope negative, bottom of electroscope positive
(C) top of electroscope positive, bottom of electroscope positive
(D) top of electroscope positive, bottom of electroscope negative

23. The diagram below shows a positively charged rod placed near, but not touching, a neutral metal ball. Which best describes what happens to the sides of the ball?



(A) X becomes negative and the ball is repelled from the rod.
(B) X becomes positive and the ball is attracted to the rod.
(C) Y becomes negative and the ball is repelled from the rod.
(D) Y becomes positive and the ball is attracted to the rod.

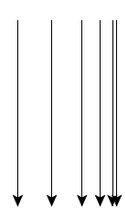
24. What is the magnitude of the electric field strength at a distance of 0.010 m from an object having a charge of 0.25 C?

(A) 5.6×10^{10} N/C
(B) 2.3×10^{11} N/C
(C) 5.6×10^{12} N/C
(D) 2.3×10^{13} N/C

25. An electric field has a strength of 130 N/C and exerts a 65 N force on a cluster of electrons. If the cluster of electrons is put through a potential difference of 450 V, how much work is done by the field?

(A) 1.1×10^{-3} J
(B) 2.3×10^{2} J
(C) 9.0×10^{2} J
(D) 3.8×10^{6} J

26. Which is true for the strength of the electric field shown?



(A) decreases downward
(B) decreases to the right
(C) increases downward
(D) increases to the right

27. Which best describes how electric field strength varies with distance in the region around a point charge?

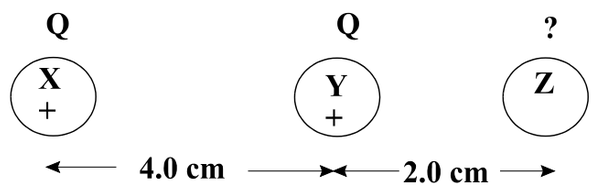
(A) $\varepsilon \propto r$

(B) $\varepsilon \propto \frac{1}{r}$

(C) $\varepsilon \propto r^2$

(D) $\varepsilon \propto \frac{1}{r^2}$

28. Three charged spheres are lined up horizontally as shown. Spheres X and Y have identical charge Q. What charge on sphere Z will result in a net force of 0 on sphere Y?



(A) − 4Q
(B) − ¼Q
(C) + ¼Q
(D) + 4Q

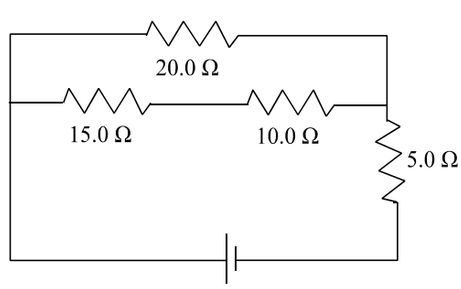
29. What is current a measure of?

(A) amount of energy given to a charged object
(B) charge passing a point in a given time
(C) number of charges stored in a cell
(D) resistance to the flow of particles

30. A piece of copper wire, with a resistance of 1000 Ω, is cut into five equal lengths that are then connected in parallel. What is the total resistance of this combination?

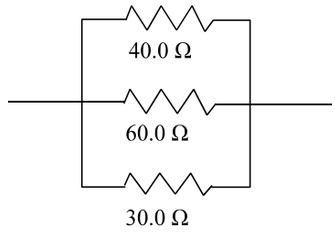
(A) 40 Ω
(B) 200 Ω
(C) 1000 Ω
(D) 5000 Ω

31. What is the total resistance of the circuit below?



(A) 9.6 Ω
(B) 12.0 Ω
(C) 16.1 Ω
(D) 50.0 Ω

32. In the circuit below, the current through the 40.0 Ω resistor is 90.0 mA. What is the current through the 60.0 Ω resistor?



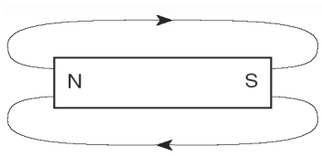
(A) 30.0 mA
(B) 45.0 mA
(C) 60.0 mA
(D) 90.0 mA

33. If a 2.0 Ω, 4.0 Ω, and 6.0 Ω resistor are connected in series with a 24 V battery, what is the potential difference across the 2.0 Ω resistor?

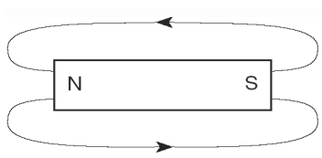
(A) 4.0 V
(B) 8.0 V
(C) 12 V
(D) 24 V

34. Which best represents the magnetic field around a bar magnet?

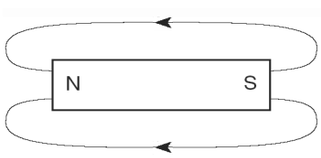
(A)



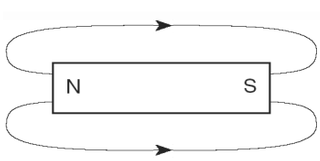
(B)



(C)



(D)



35. Who discovered that a magnetic field is created around a current-carrying wire?

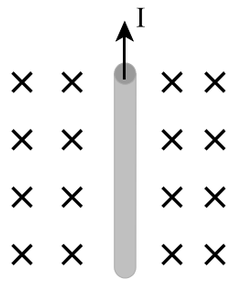
(A) Faraday
(B) Kirchoff
(C) Lenz
(D) Oersted

36. An electron travelling at 1.9×10^{4} m/s is deflected with a force of 3.0×10^{-18} N in a direction perpendicular to a magnetic field. What is the strength of the magnetic field?

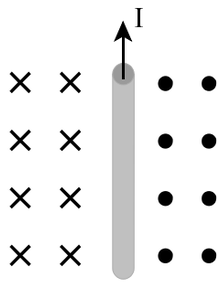
(A) 9.1×10^{-33} T
(B) 1.6×10^{-22} T
(C) 9.9×10^{-4} T
(D) 1.0×10^{3} T

37. Which shows the magnetic field on both sides of a current-carrying wire?

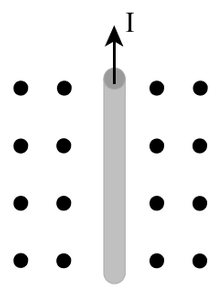
(A)



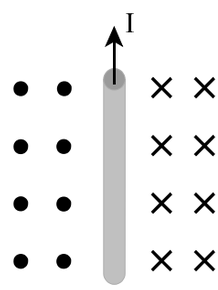
(B)



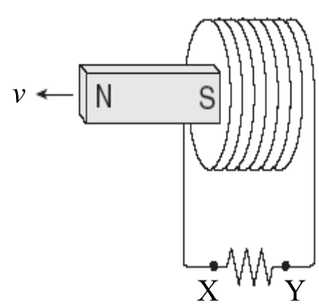
(C)



(D)



38. A bar magnet is moved away from a coil as shown. What is the direction of the induced current through the resistor and the polarity of the left end of the coil?

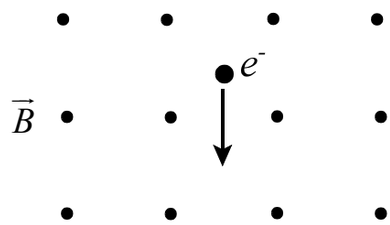


	Direction of induced current	Polarity of left end of coil
(A)	X to Y	north
(B)	X to Y	south
(C)	Y to X	north
(D)	Y to X	south

39. A wire of length 0.20 m is placed in a 0.25 T magnetic field at an angle of 35° to the field. What is the current in the wire if it experiences a force of 0.75 N?

(A) 0.038 A
(B) 0.056 A
(C) 18 A
(D) 26 A

40. An electron in a uniform magnetic field, is moving downward as shown below. What is the direction of the force on the electron?



(A) towards the bottom of the page
(B) towards the left side of the page
(C) towards the right side of the page
(D) towards the top of the page

41. Which best describes Einstein's explanation of the photoelectric effect?

(A) Light energy is concentrated in distinct "packets".
(B) Light energy is evenly distributed over the entire wave front.
(C) Metallic surfaces always absorb electrons when illuminated.
(D) Metallic surfaces always emit electrons when illuminated.

42. Which characterizes a photon of light?

(A) both energy and momentum
(B) energy, but not momentum
(C) momentum, but not energy
(D) neither energy nor momentum

43. What is the de Broglie wavelength of a neutron travelling at 5.00 m/s?

(A) 1.58×10^{-8} m
(B) 7.91×10^{-8} m
(C) 3.96×10^{-7} m
(D) 7.92×10^{-7} m

44. A metal with a work function of 4.56 eV is illuminated by light with a wavelength of 1.7×10^{-7} m. What is the maximum kinetic energy of the emitted photoelectrons?

(A) 4.4×10^{-19} J
(B) 7.3×10^{-19} J
(C) 1.9×10^{-18} J
(D) 1.5×10^{-18} J

45. If the orbital radius of an electron in a hydrogen atom is 2.12×10^{-10} m, at what energy level is the electron?

(A) 1st
(B) 2nd
(C) 4th
(D) 8th

46. How many electrons are in the atom ${}^{7}_{3}\text{Li}$?

(A) 3
(B) 4
(C) 7
(D) 10

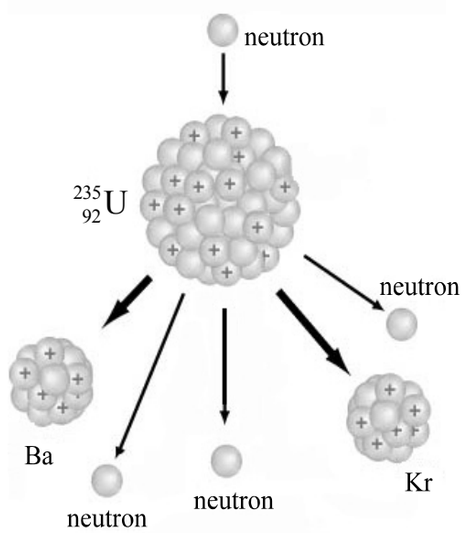
47. If a β^+ particle is emitted from an unstable nucleus, what happens to the atomic number of the nucleus?

(A) decreases by 1
(B) decreases by 2
(C) increases by 1
(D) increases by 2

48. Complete the nuclear reaction: ${}^{16}_{8}\text{O} + {}^{1}_{0}\text{n} \rightarrow \boxed{?} + {}^{4}_{2}\text{He}$

(A) ${}^{12}_{6}\text{C}$
(B) ${}^{13}_{6}\text{C}$
(C) ${}^{12}_{8}\text{C}$
(D) ${}^{13}_{8}\text{C}$

49. The diagram below illustrates part of a typical chain reaction for Uranium-235. Which nuclear equation describes the chain reaction?



(A) ${}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$
(B) ${}^{1}_{0}\text{p} + {}^{235}_{92}\text{U} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$
(C) ${}^{235}_{92}\text{U} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr} + 4\,{}^{1}_{0}\text{n}$
(D) $4\,{}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{144}_{56}\text{Ba} + {}^{89}_{36}\text{Kr}$

50. How much of a 60.0 g radioactive isotope remains after four half-lives?

(A) 3.75 g
(B) 7.50 g
(C) 9.60 g
(D) 15.0 g

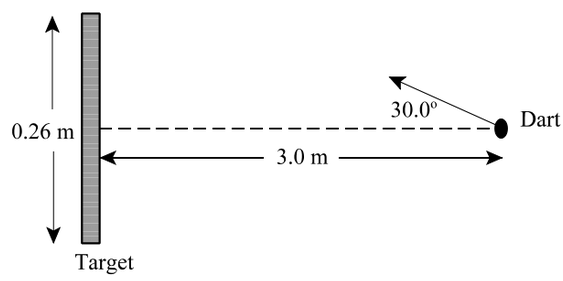
PART II
Total Value: 50%

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

3% 51.(a) A juggler throws a ball upward at an angle of 65° to the horizontal, with an initial speed of 3.2 m/s. How far apart should the juggler hold her hands in order to catch the ball at the same level from which it was thrown?

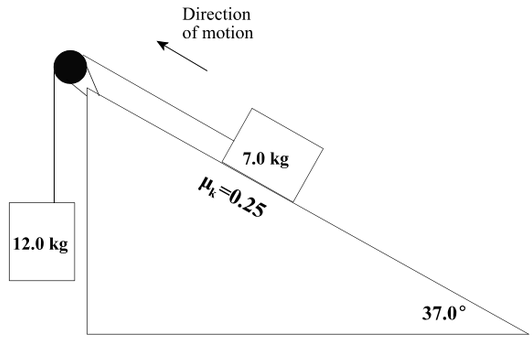
3% (b) In the diagram below a dart that is in line with the midpoint of a 0.26 m high target, is thrown toward the target with a speed of 6.0 m/s at a 30.0° angle. Determine whether the dart will hit the target if it is 3.0 m away.



Value

4% 51.(c) Two objects of masses 12.0 kg and 7.0 kg are connected by a massless string that passes over a frictionless pulley as shown.

(i) Calculate the magnitude of the acceleration of the blocks.

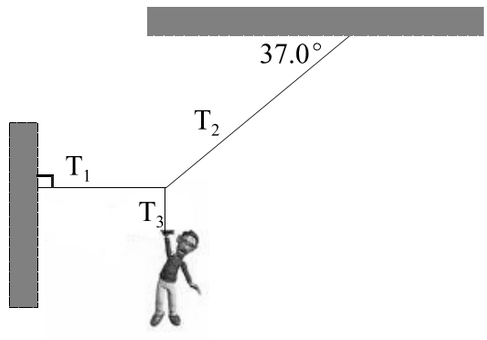


(ii) Calculate the magnitude of the tension in the string.

3% (d) A 1500 kg car travels at 25 m/s around a circular curve on a flat road. If the coefficient of static friction is 0.750, calculate the minimum radius of curvature the car can make.

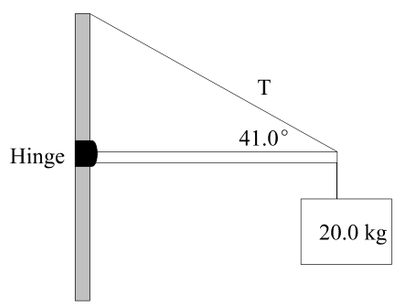
Value

3% 51.(e) A 56.0 kg person suspended by cables hangs motionless as shown. Calculate the magnitude of the tension T_1, T_2 and T_3 in each cable.



4% (f) A 20.0 kg sign is supported at the end of a 2.50 m horizontal beam of mass 21.0 kg that is hinged to a pole as shown.

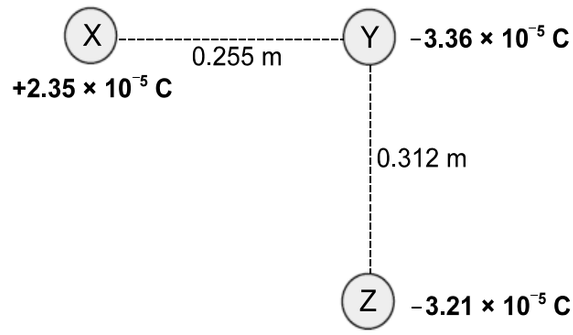
i) Calculate the magnitude of the tension in the cable.



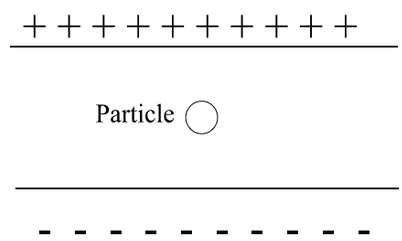
ii) Calculate the magnitude of the horizontal component of the force exerted on the beam by the hinge.

Value

3% 52.(a) Three charged spheres are arranged as shown. Calculate the magnitude of the net force on Y due to the presence of X and Z.

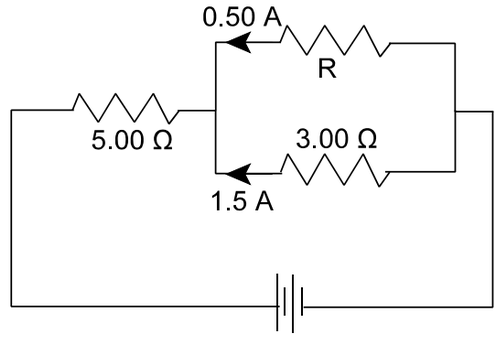


3% (b) A negatively charged particle with a mass of 5.90×10^{-15} kg is at rest between two horizontal parallel charged plates as shown. If there is an excess of 5.0×10^{2} electrons on the particle, calculate the electric field strength between the parallel plates.



Value

5% 52.(c) Given the circuit in the diagram below, calculate:



(i) the current through the 5.00 Ω resistor.

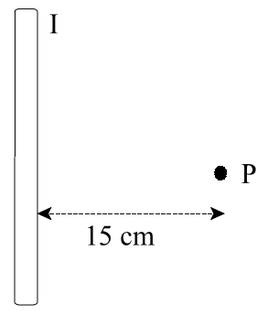
(ii) the resistance of R.

(iii) the potential difference across the battery.

3% (d) A soldering iron of resistance 576 Ω is connected to a 120 V circuit. Calculate the cost to operate the soldering iron 8.0 hours a day for 21 days, if energy costs $0.080/kW·h.

Value

3% 52.(e) The magnetic field surrounding the current-carrying wire shown below has magnitude 2.9×10^{-5} T, and is directed into the page at point P. Calculate the magnitude and direction of the current in the wire.

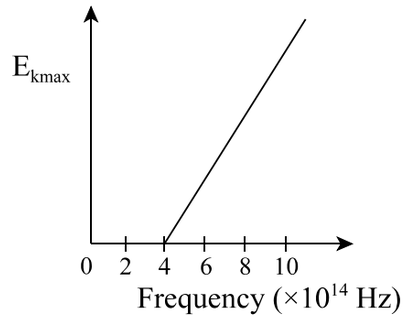


3% (f) An electron travelling at 7.7×10^{6} m/s enters a uniform magnetic field at a right angle. When inside the field, the curved path of the electron has a radius of 3.5×10^{-2} m. Calculate the magnitude of the magnetic field.

2% 53.(a) Calculate the energy (in Joules) gained by an electron in a hydrogen atom as it moves from the second to the fifth energy level.

Value

3% 53.(b) In a photoelectric effect experiment, light is shone on a metal surface. The graph below illustrates the maximum kinetic energy of ejected electrons versus frequency of the incident light of the photons.



(i) Use the graph to determine a frequency at which the photoelectric effect will **not** occur, and explain why it will not occur.

(ii) Determine the work function of the metal.

3% (c) Calculate the half-life of a radioactive substance that decays from an initial amount of 2.00×10^{-3} g to 1.35×10^{-4} g in 3.0 h.

Value

2% 53.(d) Calculate the energy produced in the reaction below.

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

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