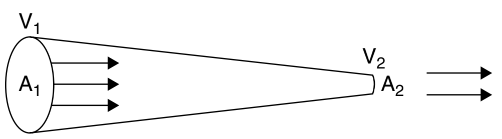
6. A cart of mass M moves at velocity **V** toward a second, stationary cart of mass m. Upon collision, the two carts become attached and move with final velocity

(A) M**V** / M-m
(B) M**V** / m
(C) (M + m) **V** / m
(D) M**V** / (M + m)
(E) 2 M**V** / (M + m)



7. Liquid passing through a narrowing tube, as shown, has a speed of 0.5 m/s at A_1 (30 cm^2). At A_2 (10 cm^2) its speed is

(A) 0.5 m/s.
(B) 1.0 m/s.
(C) 1.5 m/s.
(D) 2.0 m/s.
(E) 3.0 m/s.

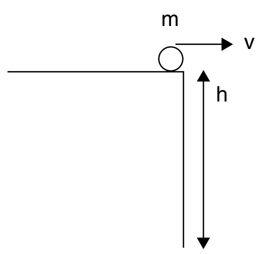
8. A concave mirror with radius of curvature 0.8 m is 0.6 m from an object. If the object is positioned on the mirror's principle axis, its image is

(A) virtual, inverted, and 0.8 m away.
(B) real, inverted, and 0.8 m away.
(C) virtual, the same size as the object, and 1.2 m away.
(D) real, erect, and 1.2 m away.
(E) real, inverted, and 1.2 m away.

9. The previous problem is repeated, but instead of the mirror, a convex lens of radii of curvature 1.6 m is used. It produces an image that is relative to the lens:

(A) virtual, erect, and 0.8 m away.
(B) real, erect, and 0.8 m away.
(C) virtual, equal in size with the object, and 1.2 m away.
(D) virtual, erect, and 2.4 m away.
(E) real, inverted, and 2.4 m away.

Questions 10–11 refer to the following figure.



10. A ball of mass m rolls off a cliff of height **h** with a horizontal velocity **v**. It reaches the ground with vertical speed of

(A) $\sqrt{\mathbf{vg}}$
(B) **hv**
(C) $\sqrt{\mathbf{2gh}}$
(D) $\mathbf{hgv^2}$
(E) $\left(\frac{1}{2}\right)\mathbf{hv^2}$

11. The ball reaches the ground after time t =

(A) (2**h** / **g**)
(B) $(2\mathbf{h} / \mathbf{g})^2$
(C) $\sqrt{\frac{2\mathbf{h}}{\mathbf{g}}}$
(D) $\sqrt{\frac{\mathbf{h}}{2\mathbf{g}}}$
(E) (**h** / 2**g**)

12. A charged parallel plate capacitor is connected to an emf ε with plate separation distance s. If the plate separation becomes s/2, the charge on the plates is

(A) quartered.
(B) halved.
(C) unchanged.
(D) doubled.
(E) quadrupled.

CliffsAP Physics B Practice Exam 2

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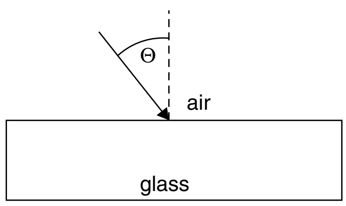
Questions 19–20 refer to the following figure.



19. A beam of light is incident on a thick glass slab (n_G) an angle Θ as shown.

I. Its reflected angle is Θ.

II. Its refracted angle < Θ and $n_G > n_{AIR}$.

III. Its refracted angle < Θ and $n_G < n_{AIR}$.

(A) I only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

20. In the previous problem, as the light passes from air into the glass, its

(A) speed and wavelength both increase.
(B) speed remains the same and its frequency increases.
(C) speed and frequency both remain the same.
(D) speed decreases and frequency remains the same.
(E) speed decreases and frequency increases.

21. In an energy exchanging experiment, 500 J of heat is added to a system while the system does 300 J of work. The change in the system's internal energy is

(A) –800 J
(B) –300 J
(C) –200 J
(D) +200 J
(E) +800 J

22. A mass M is pulled horizontally across a horizontal surface at constant velocity **V**. If the coefficient of friction between the mass and the floor is μ, at what rate is work done on the mass?

(A) M**gd**
(B) μM**gd**
(C) μM**gV**
(D) μM**V**
(E) (μM**gd**) / **V**

23. In nuclear reactions, quantities that may be conserved include

I. atomic numbers.

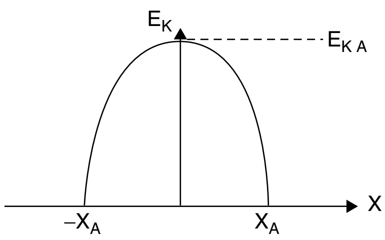
II. mass numbers.

III. electric charge.

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

24. A rock and a ping pong ball of equal volume are dropped from rest in a vacuum. At the time when each has fallen 50 cm, both objects have the same

(A) velocity.
(B) kinetic energy.
(C) momentum.
(D) potential energy.
(E) weight.



25. The illustration depicts a graph of kinetic energy E_K as a function of displacement x for an oscillating object having amplitude x_A. If the object demonstrates simple harmonic motion, the graph representing the object's potential energy E_P as a function of displacement x is

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28. While a constant current flows through the circuit, the amount of charge passing a point per second is

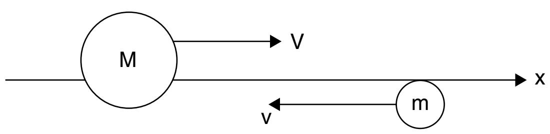
(A) greater at point **A** than at point **B.**
(B) greater in the 2 Ω resistor than in the 3 Ω resistor.
(C) greater in the 3 Ω resistor than in the 1 Ω resistor.
(D) greater in the 1 Ω resistor than in the 2 Ω resistor.
(E) the same everywhere in the circuit.

29. A 6 A current through point A means that the current through the 3 Ω resistor is

(A) 1 A
(B) 2 A
(C) 3 A
(D) 4 A
(E) 5 A

30. Which statement describes an ideal gas?

(A) The motion of the molecules is not random.
(B) Molecular collisions are inelastic.
(C) Molecular collisions do not obey Newton's Laws.
(D) There are appreciable forces of comparable magnitude acting on the molecules other than those exerted during collisions.
(E) Molecular collisions conserve momentum.



31. Two objects travel toward each other along separate paths parallel to the x-axis as shown. M = 2m. After colliding, the magnitude of the y-component of M's velocity is

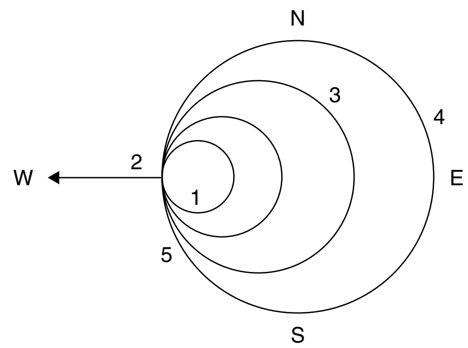
(A) $\frac{1}{4}$ the y-component of m's velocity.
(B) $\frac{1}{2}$ the y-component of m's velocity.
(C) in the same direction as m's velocity.
(D) equal to the y-component of m's velocity.
(E) twice the y-component of m's velocity.

32. The buoyant force on a hollow plastic sphere is 2 N when immersed in an unknown liquid at sea level. If the sphere has a 100 cm radius, the density of the fluid is most nearly

(A) 5×10^{-6} kg/m^3
(B) 5×10^{-5} kg/m^3
(C) 5×10^{-4} kg/m^3
(D) 5×10^{-3} kg/m^3
(E) 5×10^{-2} kg/m^3

33. A convex mirror can produce an image that is

(A) real, erect, and smaller than the object.
(B) virtual, inverted, and smaller than the object.
(C) real, inverted, and smaller than the object.
(D) virtual, erect, and smaller than the object.
(E) virtual, erect, and larger than the object.



34. A sound source at position 1 moves west with velocity **v**. The apparent frequency f and wavelength λ of the sound are

(A) lowest f, lowest λ at point 2.
(B) highest λ, highest f at point 5.
(C) lowest f, highest λ at point 3.
(D) highest λ, lowest f at point 4.
(E) highest λ, lowest f at point 1.

35. An object is placed 2 m in front of a plane mirror which produces an image that is

(A) real, erect, and located 2 m behind the mirror.
(B) real, inverted, and located 2 m behind the mirror.
(C) virtual, inverted, and located 2 m behind the mirror.
(D) virtual, erect, and located 2 m in front of the mirror.
(E) virtual, erect, and located 2 m behind the mirror.

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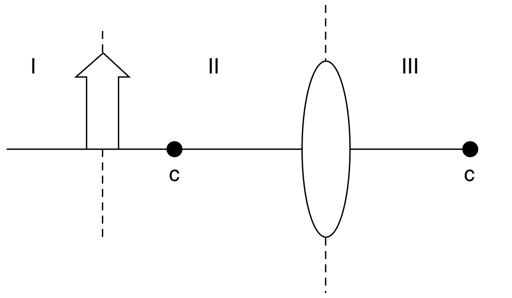
Questions 36–37 refer to the following figure.



36. In the above diagram, the object in front of the convex lens can produce an image due to refraction only, in region(s)

(A) II only.
(B) III only.
(C) I and III only.
(D) II and III only.
(E) I, II, and III.

37. The lens used in the diagram is capable of producing this number of image in general:

(A) 0
(B) 1
(C) 2
(D) 3
(E) 4

38. An amount of an ideal gas is introduced into a container of unchanging volume. Thermal energy is added to the gas, which increases its temperature from 200 K to 400 K. Before heating, the average speed of the gas molecules is $\mathbf{v_O}$ and after heating, $\mathbf{v_F}$. The ratio of $\mathbf{v_F}$ to $\mathbf{v_O}$ is

(A) $\frac{1}{\sqrt{2}}$
(B) $\frac{1}{2}$
(C) 1
(D) $\sqrt{2}$
(E) 4

39. The potential energy of an object of mass m that orbits the Moon, of mass M and radius R, at an altitude R above the Moon's surface is

(A) 0
(B)–GMm/4R
(C)–GMm/2R
(D)–GM/2R^2
(E)–GMm/R^2

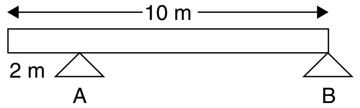
40. A 55 kg person climbs a 30° hill at a constant rate of speed of 10 m in 5 sec. What power does the person develop?

(A) 50 W
(B) 275 W
(C) 550 W
(D) 825 W
(E) 2750 W

41. A ball is launched straight up with initial velocity 15 m/s. After 2 seconds it has a total vertical displacement of

(A) 5 m
(B) 10 m
(C) 15 m
(D) 20 m
(E) 25 m

Questions 42–43 refer to the following figure.



42. A uniform 10 m-long plank weighing 150 N is supported by two blocks, A and B, as shown. The upward force supplied by block A is

(A) 23 N
(B) 36 N
(C) 54 N
(D) 94 N
(E) 101 N

43. A 10 N can of paint is placed on the plank directly over block B. The upward force supplied by block B is now

(A) 66 N
(B) 82 N
(C) 104 N
(D) 160 N
(E) 244 N

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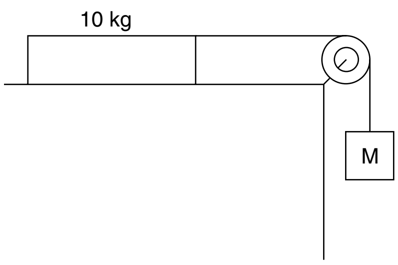
Questions 44–45 refer to the following figure.



44. The 10 kg mass is pulled to the right by an unknown mass M, over a table top which has a coefficient of friction with the 10 kg block of 0.25. The pulley is frictionless. If the 10 kg mass accelerates at 2 m/s^2, the value of the unknown mass M is most nearly

(A) 2 kg
(B) 4 kg
(C) 6 kg
(D) 8 kg
(E) 10 kg

45. Another 10 kg mass is placed atop the 10 kg mass on the table. The acceleration of the system is now most nearly

(A) 0.0 m/s^2
(B) 0.3 m/s^2
(C) 0.6 m/s^2
(D) 0.8 m/s^2
(E) 1.0 m/s^2

46. The conversion of molecules to liquid from the vapor state is

(A) vaporization.
(B) melting.
(C) freezing.
(D) regelation.
(E) condensation.

Questions 47–48

47. A rock dropped into a river 80 m below will reach the water in

(A) 2 seconds.
(B) 4 seconds.
(C) 6 seconds.
(D) 8 seconds.
(E) 10 seconds.

48. When it hits the water, the rock is traveling at a velocity of

(A) 20 m/s
(B) 30 m/s
(C) 40 m/s
(D) 50 m/s
(E) 60 m/s

49. A mountain stream flows over a cliff 120 m high. The increase in water temperature directly at the base of the waterfall is most nearly

(A) 0.1° C
(B) 0.3° C
(C) 1.1° C
(D) 2.3° C
(E) 2.8° C

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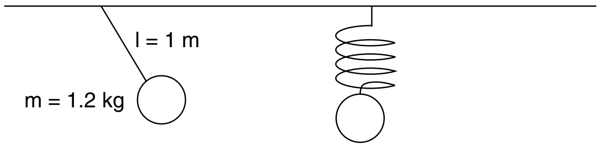
Questions 50–51 refer to the following figure.



50. A 1 m long string of negligible mass has a 1.2 kg sphere attached at the bottom, swinging back and forth as shown on the left. Its period is most nearly

(A) 0.2 seconds.
(B) 1.0 second.
(C) 2.0 seconds.
(D) 3.0 seconds.
(E) 4.0 seconds.

51. The mass is detached from the string and attached to a spring of negligible mass and k of 12 N/m, as shown on the right. When set in vertical harmonic motion, its new period is most nearly

(A) 0.2 seconds.
(B) 1.0 second.
(C) 2.0 seconds.
(D) 3.0 seconds.
(E) 4.0 seconds.

52. Units of momentum may be

(A) kgm / s^2
(B) $N \cdot s^2$
(C) $kg\ m^2 / s^2$
(D) kgm / s
(E) $J / kg\ m$

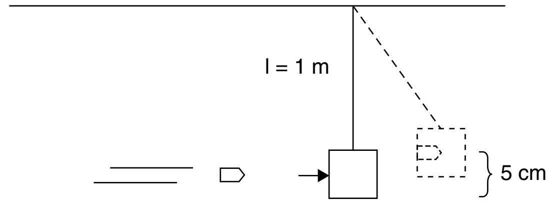
53. In compressing a spring a given distance, the work required depends on the

(A) local value for **g**.
(B) spring's mass.
(C) critical velocity.
(D) applied torque.
(E) spring constant.

54. Units of power equal

(A) $J \cdot s$
(B) $N \cdot s^2$
(C) kgm^2 / s^3
(D) W / s
(E) $W \cdot s$

Questions 55–57 refer to the following figure.



55. A bullet of mass 0.05 kg is shot at a hanging wooden block of mass 3.0 kg, which is suspended by a string of length 1 m. After striking the block, the bullet becomes embedded in it and the entire bullet-block mass rises 5 cm. The momentum of the bullet-block mass just after impact is most nearly

(A) 0.3 kg m/s
(B) 0.6 kg m/s
(C) 1.3 kg m/s
(D) 3.1 kg m/s
(E) 6.2 kg m/s

56. The kinetic energy of the system immediately after impact is

(A) 0.2 J
(B) 1.5 J
(C) 3.1 J
(D) 15 J
(E) 31 J

57. The bullet's initial velocity was most nearly

(A) 10 m/s
(B) 20 m/s
(C) 40 m/s
(D) 60 m/s
(E) 80 m/s

58. A 500 kg wagon moving at 2 m/s strikes a brick wall and stops in 0.1 sec. The average force of the wall on the wagon is

(A) 2 kN
(B) 4 kN
(C) 6 kN
(D) 8 kN
(E) 10 kN

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Fluid Mechanics and Thermal Physics

$p = p_o + \rho \mathbf{g} h$	A = area
$\mathbf{F}_{BUOY} = \rho V \mathbf{g}$	c = specific heat
$A_1 \mathbf{v}_1 = A_2 \mathbf{v}_2$	e = efficiency
$p = \rho \mathbf{g} y + 1 \rho \mathbf{v}^2 = \text{const.}$	**F** = force
$\Delta l = \alpha l_o \Delta T$	K_{AVE} = average molecular kinetic energy
$Q = mL$	k_B = Bolzmann's constant
$Q = mc\Delta T$	L = latent heat
$p = \frac{\mathbf{F}}{A}$	l = length
$pV = nRT$	M = molecular mass
$K_{AVE} = \frac{3}{2} K_B T$	m = sample mass
$V_{RMS} = \sqrt{\frac{3RT}{M}}$	n = number of moles
$= \sqrt{\frac{3\kappa_B T}{\mu}}$	p = pressure
$W = -p\Delta V$	Q = heat transferred to a system
$Q = nc\Delta T$	T = temperature
$\Delta U = Q + W$	U = internal energy
$\Delta U = nc_v \Delta T$	V = volume
$e = \left\lvert \frac{W}{Q_H} \right\rvert$	**v** = velocity
$e_c = 1 - \frac{T_C}{T_H} = \frac{T_H - T_C}{T_H}$	v = speed
	v_{RMS} = root-mean-square velocity
	W = work done on a system
	y = height
	α = coefficient of linear expansion
	μ = mass of molecule
	ρ = density

Atomic and Nuclear Physics

$E = hf = \mathbf{p}c$	E = energy
$K_{MAX} = hf - \phi$	f = frequency
$\lambda = \frac{h}{\mathbf{p}}$	h = Planck's constant
$E = mc^2$	K = kinetic energy
	m = mass
	p = momentum
	λ = wavelength
	ϕ = work function

Waves and Optics

$\mathbf{v} = f\lambda$	c = radius of curvature
$n = \frac{c}{v}$	d = slit separation
$n_1 \sin\Theta_1 = n_2 \sin\Theta_2$	f = frequency
$\sin\Theta_c = \frac{n_2}{n_1}$	f = focal length
$\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_0}$	h = height
$M = \frac{-h_1}{h_0} = \frac{-S_1}{S_0}$	L = distance
$f = \frac{c}{2}$	M = magnification
$\lambda = \frac{d \sin\Theta_m}{m}$	m = an integer
$x_m \cong \frac{m\lambda L}{d}$	n = refractive index
	s = distance
	v = speed
	x = position
	λ = wavelength
	Θ = angle

Geometry and Trigonometry

Rectangle	
$A = bh$	A = area
Triangle	C = circumference
$A = \frac{1}{2} bh$	V = volume
Circle	S = surface area
$A = \pi r^2$	b = base
$C = 2\pi r$	h = height
Paralelopiped	l = length
$V = lwh$	w = width
Cylinder	r = radius
$V = \pi r^2 h$	
$S = 2\pi rh + 2\pi r^2$	
Sphere	
$V = \frac{4}{3}\pi r^3$	
$S = 4\pi r^2$	

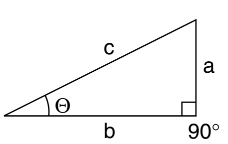
Right Triangle

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

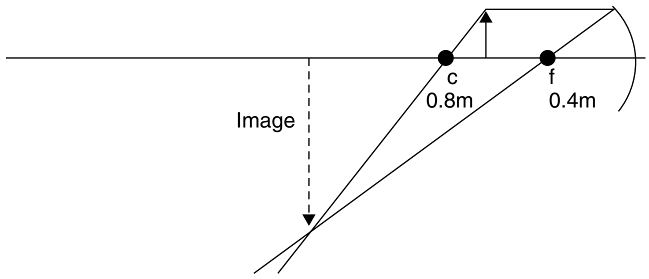
$\sin\Theta = a/c$

$\cos\Theta = b/c$

$\tan\Theta = a/b$



8. **(E)** First, draw the diagram:



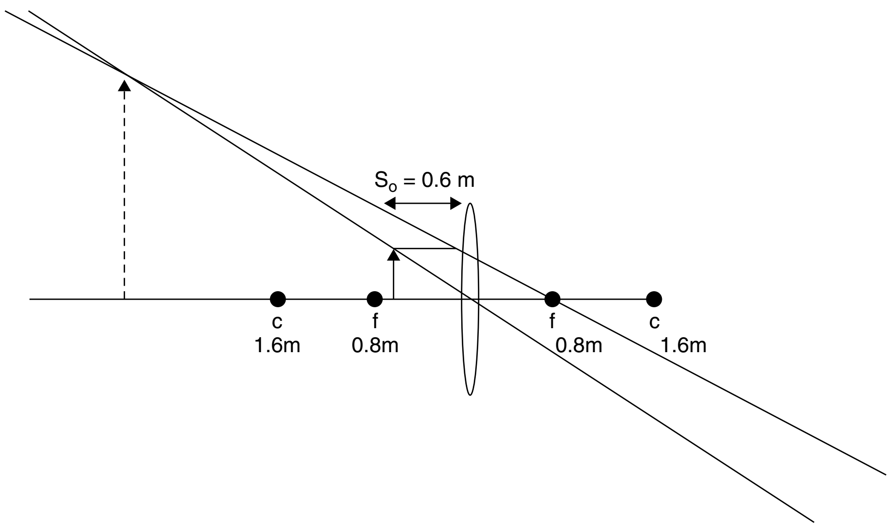
Using $1 / f = (1 / S_i) + (1 / S_O)$,

$1/ S_i = (1 / f) - (1 / S_O)$

$S_i = 1.2$ m

The image is real, inverted, 1.2 m away.

9. **(D)** First, draw the diagram:



The image is virtual and erect, on the same side as the object; therefore, S_i will be negative.

Using $(1/f) = (1/S_i) + (1/S_O)$,

$$1/S_i = (1/f) - (1/S_O) = (1/0.8\text{m}) - (1/0.6\text{m})$$

$$\mathbf{S_i = -2.4 \text{ m away}}$$

10. **(C)** Using $\mathbf{v_{FINAL\ (VERT)}{}^2 = v_{INIT\ (VERT)}{}^2 + 2\, a_{(VERT)}\, d_{(VERT)}}$

$$\mathbf{v_{FINAL\ (VERT)} = \sqrt{2gh}}$$

11. **(C)** Using $\mathbf{d_{VERT} = (v_{O\ (VERT)})(t) + (1/2)gt^2}$

$$\mathbf{h = \left(\frac{1}{2}\right)gt^2}$$

$$\mathbf{t = \sqrt{\frac{2h}{g}}}$$

12. **(D)** Using $\mathbf{C} = \frac{\kappa\varepsilon_0 A}{d} = \frac{Q}{V}$,

Charges increase with plate area increase and/or separation distance increase. **Therefore, $\left(\frac{1}{2}\right)$d doubles charge.**

13. **(D)** Using $\mu = \mathbf{F_F / F_N}$,

$$\mathbf{F_F} = \mu\, \mathbf{F_N},\ \mathbf{F_F} = (0.6)(4.0\text{ kg})(10\text{ m/s}^2) = 24\text{ N}$$
$$\mathbf{E} = \mathbf{W} = (\mathbf{F_F})(\mathbf{d}) = (24\text{ N})(2.0\text{ m}) = \mathbf{48\ J}$$

14. **(C)** Since all the kinetic energy is changed into radiant energy, $\left(\frac{1}{2}\right)m\mathbf{v}_{\mathbf{INITIAL}}^{\mathbf{2}} = 48\text{ J}$

$$\mathbf{v} = [(2)(48\text{J}) / (4.0\text{ kg})]^{\frac{1}{2}} = (24\text{m}^2/\text{s}^2)^{\frac{1}{2}} = \text{approx. } \mathbf{5\ m/s}$$

15. **(E)** Since Impulse (**J**) gives momentum (**p**),

$$\mathbf{J} = m\mathbf{v} = (0.5\text{ kg})(4.0\text{ m/s}) = \mathbf{2\ Ns}$$

16. **(D)** After the spring is released, the momentum of both sides is equal and opposite.

$$\mathbf{MV} = m\mathbf{v}$$
$\mathbf{v} = (M\mathbf{V}) / m$ but since $\mathbf{v}$ is in the opposite direction,
$$\mathbf{v = -MV / m}$$

17. **(E)** Momentum is conserved. The total momentum before release is zero; therefore, the total momentum after release is still zero. Although the directions of the masses are opposite, the **numerical magnitudes are equal.**

18. **(B)** The reflected transverse wave will be on the opposite side of the rope equal in amplitude to the original pulse, but having an opposite direction and so an opposite velocity. **(I and II only.)**

19. **(B)** The angle of incidence always equals the angle of reflection and n = sin i/sin r means that $n_G > n_{AIR}$. **(I and II only.)**

20. **(D)** When light enters a denser medium, speed decreases and frequency remains the same. (Red light stays red when it passes through glass from air.)

21. **(D)** 500 J of energy goes in, 300 J comes out, the increase in the system equals **+200 J**

22. **(C)** Power is the time rate of work or $P = \mathbf{W}/t = \mathbf{F}d/t = F\mathbf{v}$

Since the force is equal and opposite to the frictional force, $\mathbf{F_F}$, and $\mathbf{F_F} = \mu\mathbf{F_N}$,

$$P = \mu\mathbf{F_N v} = \mu\mathbf{Mgv}$$

23. **(E)** All may be conserved.

24. **(A)** All objects fall at the same rate in a vacuum, so their velocities will be equal. Since the objects have unequal masses, their weights, momenta, E_P (or m**gh**), and E_K (or $\left(\frac{1}{2}\right)\mathbf{mv^2}$) will all be unequal.

25. **(D)** As the oscillator loses potential energy, it gains kinetic energy. Since $E_K = \left(\frac{1}{2}\right)m\mathbf{v}^2$, as it gains velocity, the energy curve is parabolic in shape.

26. **(E)** Using $\mathbf{L = I\omega}$,

$$\mathbf{L} = (m\mathbf{r}^2)(\mathbf{v / r}) = m\mathbf{rv} = (4\text{ kg})(8\text{ m})(6\text{ m/s}) = \mathbf{192\ kgm^2/\ s}$$

27. **(B)** Since the **series** combination of 2 Ω and 3 Ω is in parallel with the 1Ω resistor,

$$\frac{1}{R_{EQ}} = \frac{1}{1\Omega} + \frac{1}{5\Omega} = \frac{6}{5\Omega} \text{ and } \mathbf{R_{EQ} = (5/6)}\ \Omega$$

28. **(D)** After passing point A, the current splits inversely to the branch resistance and recombines at point B. Thus, 5/6 of the main line current passes through the 1 Ω resistor and $\frac{1}{6}$ of the current passes through the 5 Ω branch.

29. **(A)** The 6 A current splits with $\frac{5}{6}$ of it going to the 1 Ω resistor and the remaining $\frac{1}{6}$ of the current going to the branch with both the 2 Ω and 3 Ω resistors.

37. **(C)** Convex lenses can produce real and virtual images.

38. **(D)** Twice the thermal energy transforms into twice the kinetic energy:

$$\mathbf{E_{K\ FINAL} = 2\ E_{K\ INITIAL}}$$
$$\left(\frac{1}{2}\right)m\mathbf{v_{FINAL}}^2 = (2)\left(\frac{1}{2}\right)m\mathbf{v_{INITIAL}}^2$$
$$\mathbf{v_{FINAL}} = \sqrt{2}\ \mathbf{v_{INITIAL}}$$

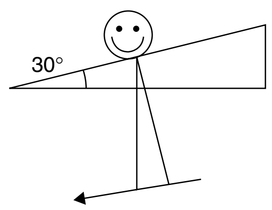
39. **(C)** Using $\mathbf{U_G} = \frac{-Gm_1m_2}{r}$, $\mathbf{U_G} = \frac{-GMm}{2R}$

40. **(C)** The person's constant velocity is 10 m/5 s = 2 m/s up the incline, which means that the force applied is equal and opposite the person's **parallel force.**

$$\mathbf{F_P} = m\mathbf{g}(\sin)\ 30° = (55\ \text{kg})(10\ \text{m/s}^2)\left(\frac{1}{2}\right) = 275\ \text{N}$$

Since P = **W**/t = **Fd**/t = **Fv = $\mathbf{F_P}$v**

$$P = (275\ \text{N})(2\ \text{m/s}) = \mathbf{550\ W}$$



41. **(B)** Using $\mathbf{d} = \mathbf{v}_O t + \left(\frac{1}{2}\right)\mathbf{a}t^2$,

$$\mathbf{d} = (15\ \text{m/s})(2\ \text{sec}) - \left(\frac{1}{2}\right)(10\ \text{m/s}^2)(2\ \text{sec})^2 = \mathbf{10\ m}$$

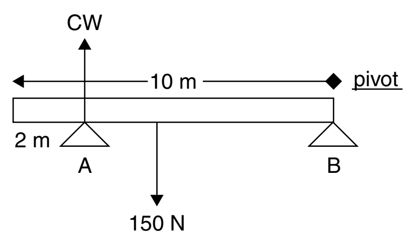
42. **(D)** Solve in two steps: First, $\Sigma\mathbf{F_{UP}} = \Sigma\mathbf{F_{DOWN}}$

$$\mathbf{F_A + F_B = 150\ N}$$

Second: $\Sigma\tau_{CW} = \Sigma\tau_{CcW}$

Arbitrarily choosing block B as the pivot:

$$\Sigma\tau_{CW} = \Sigma\tau_{CCW}$$
$$(\mathbf{F_A})(8\ \text{m}) = (150\ \text{N})(5\ \text{m})$$
$$\mathbf{F_A = 94\ N}$$



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43. **(A)** Before the paint can was added, the upward force supplied by block B was previously $\mathbf{F_B}$ = 150 N – 94 N = 56 N

Adding the can over block B supplies no additional torque if we still use B as our pivot. Therefore, now $\mathbf{F_B}$ = 56 N + 10 N = **66 N**

44. **(C)** The NET force causes the entire system to accelerate; that equals the weight of the unknown mass M minus the friction force between the 10 kg mass and the table.

$$\mathbf{F_{NET} = \Sigma ma}$$
$$\mathbf{Mg - F_F} = (M + 10\text{ kg})(2\text{ m/s}^2)$$
$$10\text{ M} - \mu\mathbf{F_N} = 2M + 20$$
$$8\text{ M} = 20 + (0.25)(10\text{ kg})(10\text{ m/s}^2)$$
$$M = 45/8\text{ kg} = \mathbf{5.6\text{ kg}}$$

45. **(B)** Once again using $\mathbf{F_{NET} = \Sigma ma}$,

$$\mathbf{a = F_{NET}} / \Sigma m$$

$$\frac{(\text{weight of hanging mass}) - (\text{friction on 20 kg masses})}{\text{total masses in the system}}$$

$$\frac{(6\text{ kg})(10\text{ m/s}^2) - (0.25)(20\text{ kg})(10\text{ m/s}^2)}{26\text{ kg}} = \mathbf{0.38\text{ m/s}^2}$$

46. **(E)** Molecules in the vapor state have more kinetic energy than those in the liquid state. When some of that energy is removed, the vapor is "cooled" and the resulting drop in kinetic energy of the molecules allows them to bind or stick to solid surfaces in the process of **condensation.**

47. **(B)** Using $\mathbf{d} = \mathbf{v_O t + (1/2)at^2}$, –80m = (–5m/s²)t² and **t = 4 seconds**

48. **(C)** Using $\mathbf{v_F}^2 = \mathbf{v_O}^2 + \mathbf{2ad}$, $\mathbf{v_F} = [(2)(-10\text{ m/s}^2)(-80\text{ m})]^{1/2}$ = **40 m/s**

49. **(B)** The water's potential energy at the top is turned into thermal energy at the bottom. Using $\mathbf{E_P} = mc\Delta t$, m**gh** = mcΔt

$$\Delta t = \mathbf{gh}/c$$
$$= \frac{(-10\text{ m/s}^2)(-120\text{ m})}{(1\text{ cal/g}^\circ\text{C})(4.19\text{ J/cal})} = \frac{1200\text{ m}^2/\text{s}^2}{4.19\text{ J/g}^\circ\text{C}} = \text{approx } 300\ \frac{\text{m}^2\text{ g}^\circ\text{C}}{\text{J s}^2}$$

Since 1 J = 1 Nm = 1 kgm²/s²:

$$\Delta t = \text{approx}\ \frac{(300\text{ m}^2\text{ g}^\circ\text{C})}{(\text{kgm}^2)}\frac{(1\text{ kg})}{(1000\text{ g})} = \mathbf{approx\ 0.3^\circ\ C}$$

50. **(C)** Using $\mathbf{T = 2\pi\sqrt{\frac{l}{g}}}$,

$$T = (2)(3.1416)\sqrt{\frac{1}{10}}$$

$$= \text{approximately } (6)(0.3) = \mathbf{approx.\ 1.98\ sec}$$

51. **(C)** Using $\mathbf{T = 2\pi\sqrt{\frac{m}{k}}}$

$$T = (2)(3.1416)\sqrt{0.1} = \mathbf{approx.\ 1.98\ sec}$$

52. **(D)** Momentum is mass times velocity, which yields units of **kg m / s**

53. **(E)** Work equals applied force times distance moved in the same direction. The restoring force of a spring equals the **spring constant k** times the distance stretched x in the opposing direction.

54. **(C)** Power is work per unit of time, or J / s, which equal Nm / s or kgm^2/s^3.

55. **(D)** Using the height that the bullet-block system reaches and setting that potential energy equal to the kinetic energy of the system immediately after impact: $\mathbf{mgh} = \left(\frac{1}{2}\right)\mathbf{mv^2}$.(cancel the m, since it represents the bullet+block mass)

$$\mathbf{v} = \left(\sqrt{2gn}\right) \text{ and momentum immediately after impact is } \mathbf{p} = (M+m)\left(\sqrt{2gn}\right)$$

$$\mathbf{p} = (3.05\text{ kg})[(2)(10\text{ m/s}^2)(0.05\text{ m})]^{\frac{1}{2}} \text{ (notice that the velocity is 1 m/s)}$$

$$= 3.05\text{ kgm/s} = \textbf{(closest) 3.1 kg m/s}$$

56. **(B)** Using $\mathbf{E_K} = \left(\frac{1}{2}\right)\mathbf{mv^2}$,

$$E_K = \left(\frac{1}{2}\right)(3.05\text{ kg})(1\text{ m/s})^2 = \mathbf{1.5\ J}$$

57. **(D)** Setting momentum before impact equal to total momentum immediately after impact,

$$(\mathbf{m_{BULLET}})(\mathbf{v_{O\ BULLET}}) = (\mathbf{M+m})(\mathbf{v_{F\ B+B}})$$
$$\mathbf{v_{O\ BULLET}} = (3.05\text{ kg})(1\text{ m/s}) / (0.05\text{ kg}) = \mathbf{62\ m/s}$$

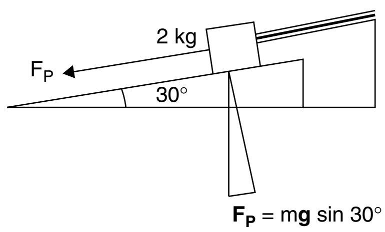
58. **(E)** Using **FΔ t = mΔv (“Impulse gives momentum”)**,

$$\mathbf{F} = (m\Delta\mathbf{v}) / t = (500\text{ kg})(2\text{ m/s}) / 0.1\text{ sec} = 10,000\text{ N} = \mathbf{10\ kN}$$

59. **(B)** Efficiency = Work out / work in or **Power out / power in**.

60. **(B)** Set the parallel force equal to the spring’s restoring force: $\mathbf{F_P = -kx}$

$$-k = (m\mathbf{g}\sin 30°) / \mathbf{x}$$



$$-k = \frac{m\mathbf{g}\sin 30°}{x} = \frac{(2\text{ kg})(-10\text{ m/s}^2)\left(\frac{1}{2}\right)}{(0.1\text{ m})} = k = \mathbf{100\ N/m}$$

61. **(D)** Using $\mathbf{d = v_O t + (1/2)at^2}$,

$$d = \left(\frac{1}{2}\right)(10\text{ m/s}^2)(\sin 30°)(1\text{ sec})^2 = \mathbf{2.5\ m}$$

62. **(B)** Using $\mathbf{R} = \frac{\rho 1}{A}$ and assigning **r** to the small square and **R** to the large one:

$$\frac{r}{R} = \frac{1}{L} \text{ and } \mathbf{r} = \frac{1R}{L} \text{ (the } \rho \text{ and A for both wires are the same)}$$

$$\mathbf{r} = 4s\ R / 8s = \left(\frac{1}{2}\right)\mathbf{R}$$

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3. **(a)** Using $\boldsymbol{\tau = Fr = I\alpha}$, the net force is provided by the 3 kg mass minus the Force to accelerate it.

$$\mathbf{I\alpha = F_{NET}r}$$
$$\left(\frac{1}{2}\right)(m)(\mathbf{r}^2)(\boldsymbol{\alpha}) = [(m_{3kg})(\mathbf{g}) - (m_{3kg})(\mathbf{a})]\mathbf{r}$$
$$\left(\frac{1}{2}\right)(30\text{ kg})(\mathbf{r})^2(\boldsymbol{\alpha}) = [(3.0\text{ kg})(9.8\text{ m/s}^2) - (3.0\text{ kg})(\mathbf{a})]\mathbf{r}$$
$$(15\text{ kg})(0.3\text{ m})(\boldsymbol{\alpha}) = (29.4\text{ kg m/s}^2) - (3.0\text{ kg})(\mathbf{a})$$
$$(4.5\text{ kgm})(\boldsymbol{\alpha}) = (29.4\text{ kg m/s}^2) - (3.0\text{ kg})(\mathbf{a})(0.3\text{m})$$
$$(5.4\text{ kgm})(\boldsymbol{\alpha}) = 29.4\text{ kgm/s}^2$$
$$\boldsymbol{\alpha = 5.4\text{ rad/s}^2}$$

(b) Using $\mathbf{a} = \boldsymbol{\alpha}\mathbf{r}$,

$$\mathbf{a} = (5.4\text{ rad/s}^2)(0.3\text{ m/rad}) = \mathbf{1.6\text{ m/s}^2}$$

(c) Using $\boldsymbol{\Theta = \omega_o t + \left(\frac{1}{2}\right)\alpha t^2}$,

$$\boldsymbol{\Theta} = (0) + \left(\frac{1}{2}\right)(5.4\text{ rad/s}^2)(5\text{ sec})^2(1\text{ rev}/2\pi\text{ rad})$$
$$= \mathbf{11\text{ revolutions}}$$

(d) Again, using $\mathbf{I\alpha = F_{NET}(r)}$, $\mathbf{I\alpha = F_{NET3}(r_3) - F_{NET2}(r_2)}$

$$\left(\frac{1}{2}\right)(30\text{ kg})(\mathbf{r}^2)(\boldsymbol{\alpha}) = (m_3g\text{-}m_3a)(r_3) - (m_2g\text{-}m_2a)(r_2)$$
$$1.4\text{ kgm}^2/\text{rad}^2\,\boldsymbol{\alpha} = (m_3g\text{-}m_3\boldsymbol{\alpha}r_3) - (m_2g\text{-}m_2\boldsymbol{\alpha}r_2)(r_2)$$
$$1.4\text{ kgm/rad}^2\,\boldsymbol{\alpha} = [(3.0\text{ kg})(9.8\text{m/s}^2\text{-}(3\text{ kg}) - (\boldsymbol{\alpha})\ (3.0\text{ m/rad})]r_3$$
$$- [(2.0\text{ kg})(9.8\text{ m/s}^2) - (2\text{ kg})\ (\boldsymbol{\alpha})\ (0.03\text{ m/rad})]r_2$$
$$1.4\ \boldsymbol{\alpha} = (8.82 - 2.7\ \boldsymbol{\alpha}) - (0.59 - 0.0018\boldsymbol{\alpha})$$
$$\boldsymbol{\alpha} = 2.0\text{ rad/s}^2$$

(e) Using $\mathbf{a} = \boldsymbol{\alpha}\mathbf{r}$,

$$\mathbf{a} = (2.0\text{ rad/s}^2)(0.3\text{ m/rad}) = \mathbf{0.6\text{ m/s}^2}$$

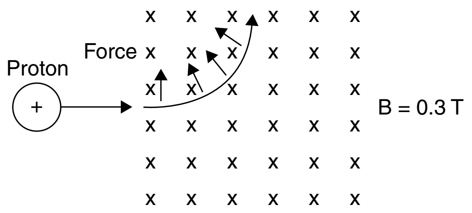
(f) Using $\boldsymbol{\Theta = \omega_o t + \left(\frac{1}{2}\right)\alpha t^2}$,

$$\boldsymbol{\Theta} = (0) + \left(\frac{1}{2}\right)(2.0\text{ rad/s}^2)(5\text{ sec})^2(1\text{ rev}/2\pi\text{ rad}) = \mathbf{4.0\text{ revolutions}}$$

5. **(a)** Using $\mathbf{F_M = qv \times B}$,

$$\mathbf{F_M} = (+1.60 \times 10^{-19}\,\text{C})(2.0 \times 10^{6}\,\text{m/s})(0.3\text{T}) = \mathbf{9.6 \times 10^{-14}\ N}$$

(b)



(c) Since the force that pulls the proton into the circular path is a centripetal force, equate $\mathbf{F_M}$ and $\mathbf{F_C}$:

$$\mathbf{qv \times B = \frac{mv^2}{r}}$$

$$9.6 \times 10^{-14}\,\text{N} = \frac{(1.67 \times 10^{-27}\,\text{kg})(2.0 \times 10^{6}\,\text{m/s})^2}{\text{r}} \text{ and r} = 7.0 \times 10^{-2}\,\text{m}$$

(d) If the entering charge is an electron, the force due to the magnetic field is equal but in the opposite direction, since protons and electrons have equal but opposite electric charges. Therefore, the magnitude of the force would be the same as on the proton, 1.9×10^{-13} N.

Equating this force with the centripetal force for the electron:

$$\mathbf{qv \times B = \frac{mv^2}{r}}$$

$$9.6 \times 10^{-14}\,\text{N} = \frac{(9.11 \times 10^{-31}\,\text{kg})(2.0 \times 10^{6}\,\text{m/s})^2}{\text{r}} \text{ and r} = 3.8 \times 10^{-5}\,\text{m}$$

The ratio of radii is:

$$\frac{7.0 \times 10^{-2}\,\text{m for the proton}}{3.8 \times 10^{-5}\,\text{m for the electron}}$$

The radius of the proton's circular path is **about 1800 times that of the electron.**