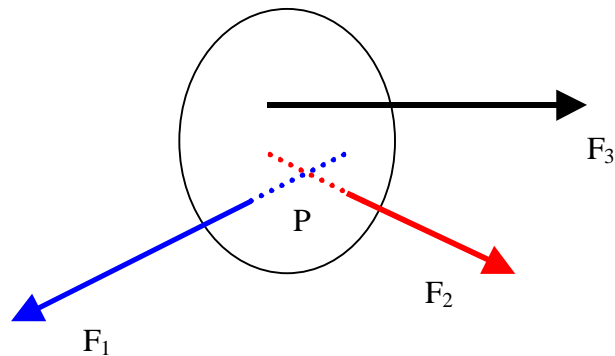


2001 AL Physics MC Suggested Solution

1. E.

Any three forces acting on a body must pass through the same point (concurrent) if the body is in an equilibrium.

Suppose an object is acted by three non-parallel forces. .



Let point P be the intersection point of F_1 and F_2 (P must exist because the two forces are not parallel).

Take moment about P,
 moment produced by $F_1 = 0$
 moment produced by $F_2 = 0$
 moment produced by $F_3 \neq 0$

Thus the object could not be in equilibrium as long as F_3 does not pass through P

2. B.

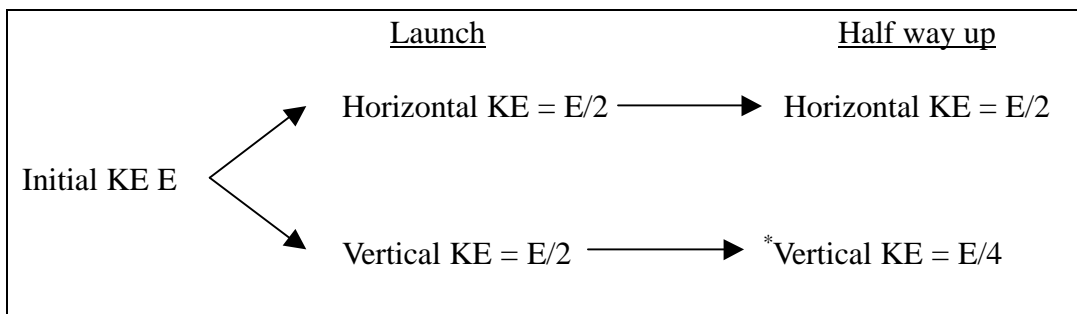
- Centripetal force is provided by the weight of the satellite.
- Air resistance: force acting on the object by the air
- Weight: force acting on the object by the Earth
- Attraction between two current-carrying wire:

Wire A exerts a force on **wire B**; **wire B** exerts a force on **wire A**.

3. C.

$$\text{Horizontal KE} = m(v \cos 45^\circ)^2 / 2 = mv^2 / 4 = E/2$$

$$\text{Vertical KE} = m(v \sin 45^\circ)^2 / 2 = mv^2 / 4 = E/2$$



*At the halfway one, one-half of the vertical KE is converted into PE.

4. A.

- (1) Impulse is the change in momentum, it is a vector.
- (2) Moment of inertia is a scalar.
- (3) Pressure is defined as the magnitude of the normal component of the force acting on unit area. It is a scalar.

Pressure is NOT \vec{F}/A , it is defined as $(\vec{F} \cdot \vec{n})/A$, where \vec{n} is the unit normal vector of the surface.

5. A.

Let XZ = d

$$v^2 = u^2 + 2ad \dots \dots \dots (1)$$

Let the speed at Y be w.

$$w^2 = u^2 + 2ad/2 \dots \dots \dots (2)$$

Eliminate ad,

$$v^2 = u^2 + 2(w^2 - u^2)$$

Hence, we can solve w.

6. C

- (1) $a \propto -x$. Max displacement \rightarrow max restoring force (in value)
 - (2) $PE \propto x^2$
 - (3) The object reverses its motion at a point of max displacement, so velocity = 0
-

7. E.

$$x^2 + (v/\omega)^2 = A^2$$

Max speed: $x = 0$, $v = 1 \text{ ms}^{-1}$, $A = 0.3 \text{ m}$ Displacement 0.3 m: $x = 0.3 \text{ m}$, $v = ?$, $A = 0.3 \text{ m}$

8. C

Only two forces are acting on the bob: weight and tension.

The net force of them acts along the direction of motion of the bob.

9. E

(I) $mgh = mv^2/2 + I\omega^2/2$, where $\omega = v/r$

Translational KE + Rotational KE = constant

Translational KE : Rotational KE = $m : I/r^2$.

Solid cylinder has a smaller M.I, so it possesses a smaller rotational KE.

(II) WD against friction = 0 ?

In fact, to the rolling cylinder, there are two "types" of WD against friction.

Type 1: friction \times sliding distance = energy dissipated as thermal energy
(sliding distance = distance translated – arc length rotated)Type 2: friction \times distance moved by the center of mass = change in rotational KE.

In rolling without sliding, the former is zero but not the latter.

10. A.

The tension in the string is always radial, so the torque produced by it is zero.

The total angular momentum is therefore conserved.

 $Mvr = Mv'(r/2) \rightarrow v' = 2v \rightarrow$ KE is four times larger.

11. D

wavelength = $3 \times 10^8 / 9192631770 = 0.03 \text{ m} = 3 \text{ cm}$
 (microwaves used in our lab is 3 cm wavelength)

12. E

13. E.

1 cm slit separation is too large for the two light beams to have enough diffraction to cause interference.

14. A.

- (1) The focal length of the lens should be as long as possible, so the rings are well-separated.
 - (2) The separation between adjacent rings decreases with radius.
 - (3) If the contact at the center is "good", the spot appearing there is dark. Introducing liquid between the lens and the reflector does not make any change.
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15. D

When the intensity is doubled, the sound level is increased by 3 db

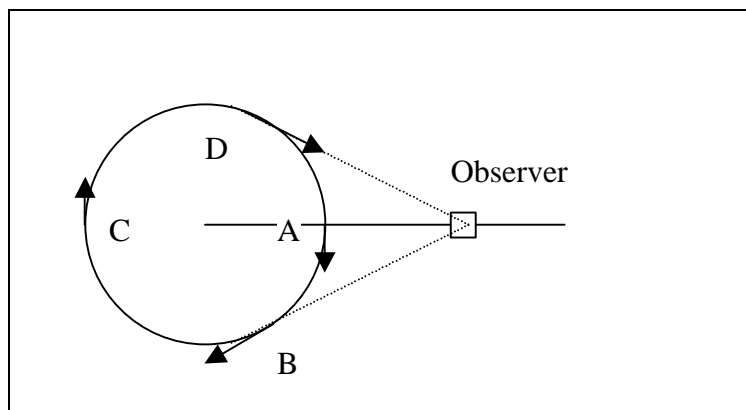
$$(60-40)/3 = 6.67$$

The intensity is increased by $2^{6.67}$, i.e 100 times larger.

16. A

17. D

18. D



Sound of a higher pitch is heard when the source is leaving.

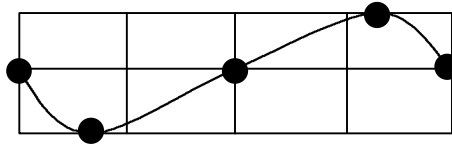
Sound of a lower pitch is heard when the source is approaching

When the source is moving upward or downward, the pitch does not change.

At A and C, $f = f_0$.

On the arc ABC, $f < f_0$. The minimum occurs at B, at where the source is directly leaving. From A to B, the time is less than $T/4$.

On the arc CDA, $f > f_0$. The maximum occurs at D, at where the source is directly approaching. From A to D, the time is more than $3T/4$.



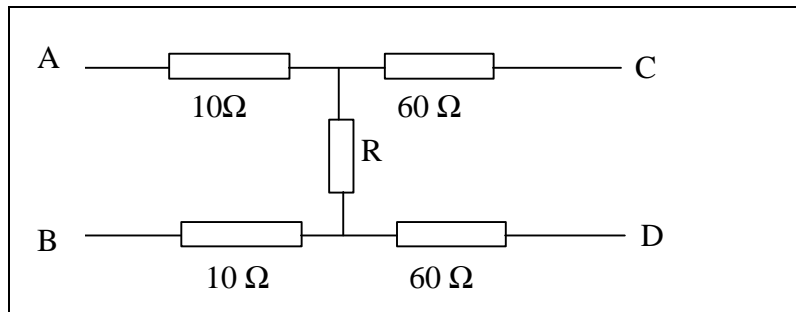
19. D

20. A.

(2) The electrons come from the earth, not Y.

(3) (4) Both X and Y are earthed, so potential = 0.

21. C



A voltage source of 100 V is applied across AB, the p.d. across CD is 80 V. Note that CD is open, so there is no current passing the two 60 Ω resistors.

$$\text{p.d. across } R = 80 \text{ V}$$

$$\rightarrow \text{p.d. across each } 10 \Omega \text{ resistor} = 10 \text{ V}$$

$$\rightarrow R = 80 \Omega$$

When the source is connected across CD,

$$\text{p.d. across } R = 100 \left(\frac{80}{60 + 80 + 60} \right) = 40 \text{ V}$$

22. D

X: 6V, 12 W, 2A, 3Ω

Y: 6V, 3W, 0.5A, 12Ω

To divide the 12 V by two equal amounts, each part is 6 V.

$R_Y > R_X$. By connecting a suitable resistor in parallel with Y to make their equivalent resistance as same as R_X .

23. B

$$Q = CV \rightarrow \Delta Q = C(\Delta V)$$

Initially, each plate contains $500 \mu\text{C}$ and the p.d. across them is zero.

By transporting a charge of $+400 \mu\text{C}$ from one plate to the other, the p.d. becomes 4 V ,

$$C = 400 \mu\text{C}/4\text{V} = 100 \mu\text{F}$$

24. A

$$(1) Q = CV = 2C. 1 \text{ mA} \times 2000\text{s} = 2 \text{ C}$$

(2) The charge will drop by 63% after the time RC .

$$(3) \text{Energy stored} = CV^2/2 = 20\text{J}$$

25. A

$$C = \frac{\epsilon_0 A}{d} \quad \text{Now } d \rightarrow 1.2d$$

$$C' = \frac{\epsilon_0 A}{1.2d} = 0.83 \frac{\epsilon_0 A}{d} = 0.83C$$

The capacitance will decrease by 17 %

26. C

$$(1) \text{Flux linkage } \Phi = LI$$

$$(2) \text{Induced emf} = -d(N\Phi)/dt$$

$$(3) \Phi = BA \text{ (Weber is tesla-meter}^2\text{)}$$

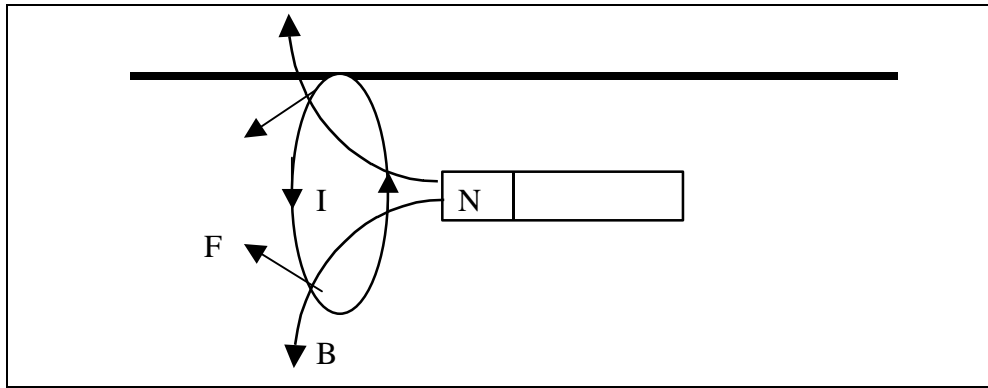
27. D

Magnetic field: no beginning, no end;

Electric field: from positive to negative charge

28. E

Suppose a N-pole is approaching. A current will be induced in the loop. This current, along with the magnetic field produced by the magnet will produce a force around the loop. As indicated in the diagram, the loop is repelled and shrinks.



However, the loop will exert a repelling force on itself (two wires will repel when they carry currents flowing in the opposite direction). This makes the loop to expand. The shrinking force is proportional to the induced current, while the expanding force is proportional to the square of induced current ($F = BiI$, B is proportional to i as well). So the latter is a so-called "second-order effect" and usually neglected. Is it possible for the expanding force to win? Yes, it is. If the wire is made of a conductor of very low resistance, the induced current may be very large and hence the second-order effect may dominate.

29. D

- (1) The metallic frame on which the wire is wound causes damping as it rotates in the B-field.
- (2) Radial force is necessary for the linear scale.
- (3) Weak hair springs \rightarrow stop before turning a larger angle

30. B

Power dissipated = $I_{\text{rms}}^2 R = 2^2(5) = 20\text{W}$
 The inductive reactance does not dissipate energy

31. C.

The x-sweep of Graph C is a linear function of time. (time base —saw-tooth signal)

32. B

Maxwellian distribution

33. E

$$\Delta U = Q + W$$

WD on the gas: U is increased, so $W > 0$

WD by the gas: U is decreased, so $W < 0$

The gas is now compressed, so $W > 0$

V decreased, P constant \rightarrow T decreased ($PV/T = \text{constant}$) \rightarrow U decreased

$$\Delta U < 0, W > 0 \rightarrow Q < 0$$

34. B

Photoelectric effect ---- use the concept "photon", which are discrete lumps of energy

Emission of γ rays ----- γ rays are photons.

Nuclear fission ----- The (introductory) theory does not require the concept "discrete amounts" .

35. E

$$\text{Force } F = - \frac{dU}{dr}$$

Positive force is repulsive, negative force is attractive

36. B

	Percentage error
Length of steel wire	$0.01/1.96 = 0.5\%$
Diameter of steel wire	$0.01/0.61 = 1.6\%$
Mass of the load	$0.01/10.00 = 0.1\%$
Extension	$0.1/3.9 = 2.6\%$
Acceleration	$0.1/9.8 = 1\%$

Young modulus $E = FL/Ae$

A is proportional to diameter² , so the error contributed by it is 3.2 %.\

37. E

(1) Steeper of the elastic region \rightarrow Stiffer

(2) Higher peak of the plastic region \rightarrow stronger

(3) Max strain of $Z = 1.5$, so max extension = 1.5 original length.

Whole length = 2.5 original length

38. C

(1) (2) $A_v = \text{constant}$. $A_x = A_z > A_y$, so $v_x = v_z < v_y$

(3) The highest the speed, the lowest the pressure.

39. C

The frequency of red light is lower than that of yellow light.

40. A

To hydrogen atoms, $E_n = -E_0/n^2$

	Energy change
$n = 2$ to $n = 1$	$3E_0/4$
$n = 3$ to $n = 2$	$5E_0/36$
$n = 4$ to $n = 3$	$7E_0/144$
$n = 4$ to $n = 2$	$12E_0/64$
$n = 5$ to $n = 2$	$21E_0/100$

41. B

$$\text{Output loop, } 6\text{V} = I_C(2\text{k}\Omega) + 2\text{V} \rightarrow I_C = 2 \text{ mA}$$

$$I_B = 0.002/100 = 0.00002 \text{ A}$$

$$\text{Input loop, } 6 \text{ V} = (0.00002)R + 0.6 \rightarrow R = 270 \text{ k}\Omega$$

42. B

Property of exponential decay: The value drops by the same fraction after the same time interval.

$$\frac{N_0}{70} = \frac{70}{49}, \text{ so } N_0 = 100 \text{ Bq}$$

43. B

44. C

$$\text{Binding energy per nucleon} = (1.0078 + 1.0087 - 2.0146)931/2 = 0.88 \text{ MeV}$$

45. D

$$\text{X: } 480/119 = 2^n \rightarrow n = 2$$

$$\text{Y: } 135/9 = 2^n \rightarrow n = 3.9$$

$$\text{Z: } 168/93 = 2^n \rightarrow n = 0.85$$

Penetrative power is irrelevant to decay constant.

Y has the largest decay constant

$t_{1/2} = \ln 2 / \lambda$. Z has the smallest decay constant, so the longest half-life.
