2001 HKAL Physics MC Suggested Solution

1. E.

(i) Weight of the block acts downward at its center.

(ii) Frictional force acts tangentially at the bottom surface.

(iii) The three forces must pass through the same point (concurrent).

A famous "theorem" in mechanics:

When a body is in equilibrium under the application of three non-parallel forces, the three forces must be concurrent.

Consider the following example:

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

Let point A be the intersection point of the red force and the blue force (it must exist because the two forces are not parallel).

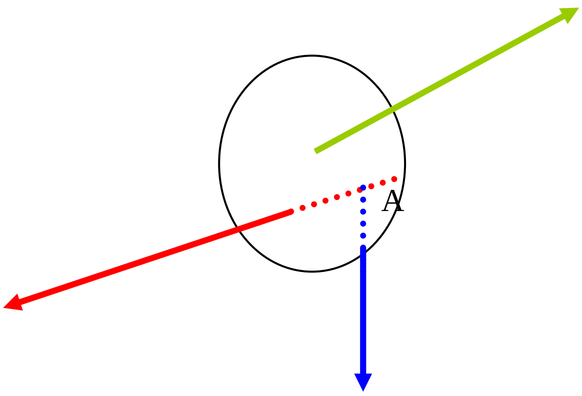
Take moment about A,

moment produced by the red force = 0

moment produced by the blue force = 0

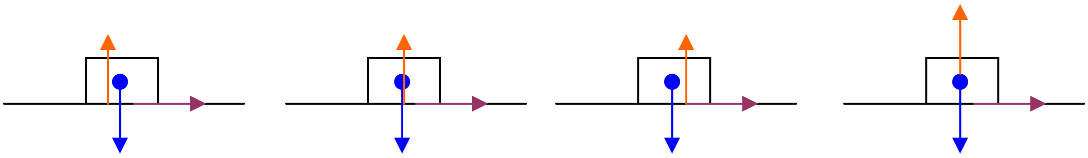
moment produced by the green force $\neq$ 0

The object rotates about A, so it is not in equilibrium. To satisfy the condition of net moment = 0, the green force must pass through A as well.



Further Question:

When an object slides on a rough horizontal plane, which of the following graphs correctly shows the lines of application of all the forces?



A B C D

Ans : A

2. B

(1) Centripetal force is provided by the weight of the satellite.

(2) Air resistance: force acting on the object by the air
Weight: force acting on the object by the Earth

(3) Attraction between two current-carrying wires:
Wire A exerts a force on wire B; wire B exerts a force on wire A.

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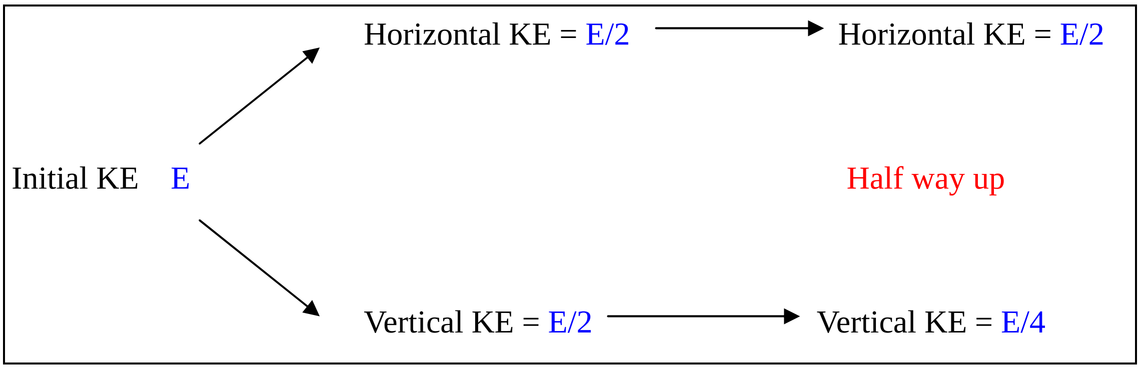
3. C.

Horizontal KE = $m(v\cos 45^o)^2/2 \quad = mv^2/2 = E/2$

Vertical KE = $m(v\sin 45^o)^2/2 \quad = mv^2/2 = E/2$



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

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4. A.

(1) Impulse in 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 ($\vec{F} \bullet \vec{n}$)/A, where $\vec{n}$ is the unit normal vector of the surface.

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5. A.

Let XZ = d

$v^2 = u^2 + 2ad$ …………..(1)

Let the speed at Y be w.

$w^2 = u^2 + 2ad/2$ ………….(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 → 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 = $1ms^{-2}$, A = 0.3m

Displacement 0.3 m: x = 0.3 m, v = ?, A = 0.3 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 (C is controversial)

(I) $mgh = mv^2/2 + I(v/r)^2/2$

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) A debate

(a) Arguments supporting "WD against friction is zero"

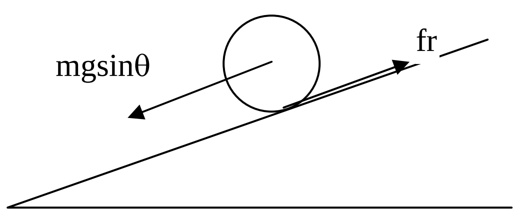
The contact point, relative to the inclined plane, is stationary.

No slipping occurs between the two surfaces, so WD against friction is zero.

A strong evidence is that there is no mechanical energy loss in the system.

(b) Arguments supporting " WD against friction is NOT zero".

Let us analyze the problem from Newton's law



The cylinder rolls downward with acceleration. The friction fr produces a torque about its center, so the angular speed can keep in pace with the increasing translational speed.

acceleration a = $\dfrac{mg\sin\theta - fr}{m}$

$v^2 = u^2 + 2ax$

$= u^2 + 2\ (\dfrac{mg\sin\theta - fr}{m})(\dfrac{h}{\sin\theta})$

Rearranging the terms,

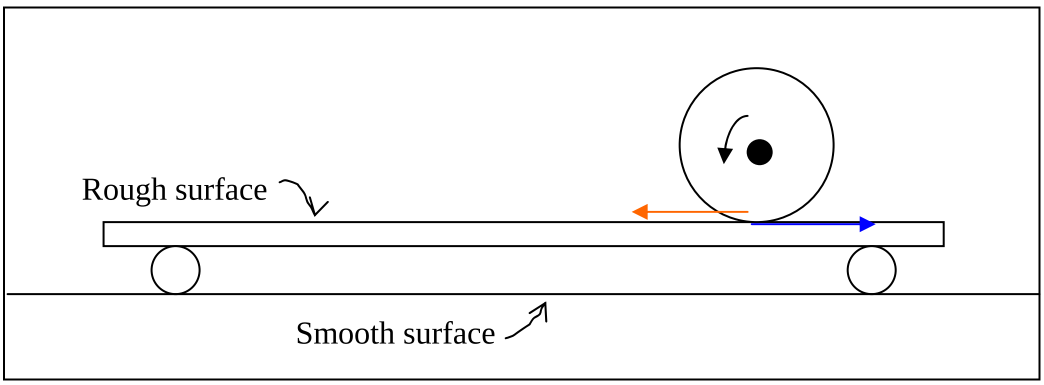
$$fr(\frac{h}{\sin\theta}) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 + mgh \quad \ldots\ldots\ldots\ldots\ldots(*)$$

The LHS is just the WD against friction.
On the other hand, the total mechanical energy is conserved, so the LHS of (*) can be identified as the increase in rotational kinetic energy.
So, WD against friction = change in rotational KE.

Consider another example:

A stationary disc is put on the top of a long cart. The disc is now made to rotate with its axle unmoved. The angular speed increases with time. Assume the contacting surface is rough, so friction must appear. In the diagram, the red force is the friction acting on the disc by the cart, and the blue force is the friction acting on the cart by the disc. In addition, we assume no slipping, hence relative to the cart, the speed of the lowest point of the disc is zero.

After a while, the cart will move to the right with an increasing KE. Where does its KE come from ? Obviously, energy is delivered to the disc through the WD by the friction.
The disc rolls with no sliding, but the blue (or red) friction does work to enable the energy transfer.



(III) OK, which side is correct ?

Please think thoughtfully and consult your teacher.

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10. A.

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

The total angular momentum is therefore conserved.

Mvr = Mv'(r/2) → v'=2v → KE is four times as large.

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11. D

wavelength = 3 x 10^8 /9192631770 = 0.03 m = 3 cm

(microwaves used in our lab is 3 cm wavelength)

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12. E

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13. E.

The slit separation = 1 cm is too large. If so, the two light beams do not diffract enough to produce 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 26.67 , i.e 100 times larger

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16. A

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17. D

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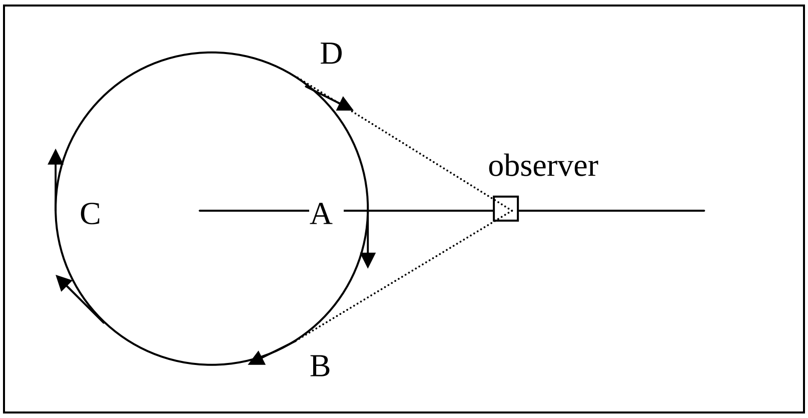
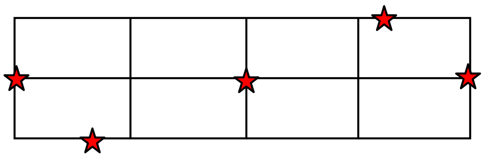
18. D



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 leaving directly from the observer. 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 approaching directly towards the observer. From A to D, the time is more than 3T/4.



Draw a curve to connect the points.

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19. D

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20. A.

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

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

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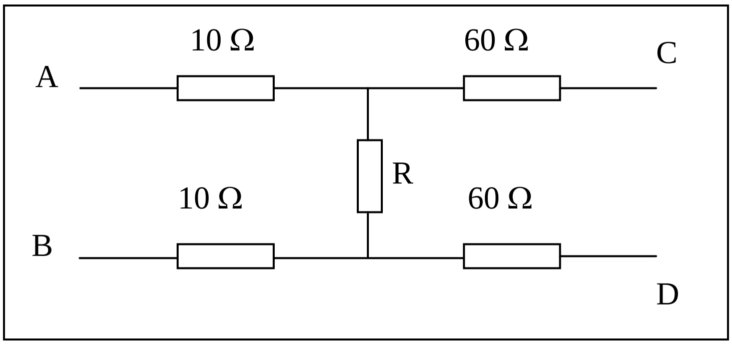
21. C



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.

p.d. across R = 80 V

➔ p.d. across each 10 Ω resistor = 10 V

➔ R = 80 Ω

When the source is connected across CD,

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

p.d. across AB = 40 V

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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.

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23. B

Q = CV ➔ ΔQ = C(ΔV)

Initially, each plate contains 500 μC and the p.d. across them is zero.

By transporting a charge of +400 μC from one plate to the other, the p.d. becomes 4 V,

C = 400 μC/4V = 100 μF

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24. A

(1) Q = CV = 2C. 1 mA x 2000s = 2 C

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

(3) Energy stored = $CV^2/2$ = 20J

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25. A

$$C = \frac{\varepsilon_o A}{d} \qquad \text{Now } d \rightarrow 1.2\ d$$

$$C' = \frac{\varepsilon_0 A}{1.2d} = 0.83\ \left(\frac{\varepsilon_0 A}{d}\right) = 0.83\ C$$

The capacitance will decrease by 17 %

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26. C

(1) Flux linkage Φ = LI

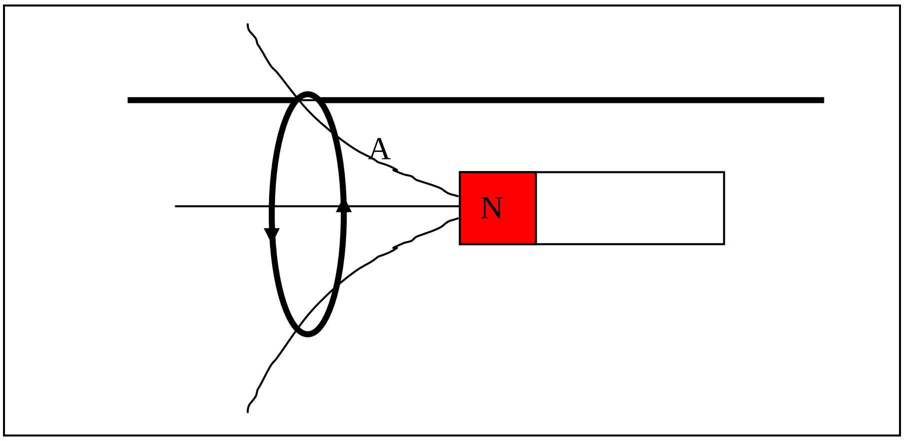
(2) Induced emf = -d(NΦ)/dt

(3) Φ = BA (Weber is tesla-meter^2)

27. D

Magnetic field: no beginning, no end;
Electric field: from positive to negative charge

28. E



Suppose a N-pole is approaching. Current will be induced in the loop such that the loop will be repelled. To each part of the loop, the magnetic field produced by the magnet has a horizontal component. This component of B will create an inward force towards the center around the loop. The loop will thus tends to shrink.
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.

These two forces are competitive, which one is more important?
The shrinking force is proportional to the induced current, while the expanding force is proportional to the square of induced current (F = Bil, while B is proportional to i as well). So the latter is a so-called "second-order effect" and usually neglected.

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 → stop before turning a larger angle

30. B

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

31. C.

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

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32. B

Maxwellian distribution

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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 → T decreased (PV/T = constant) → U decreased

$\Delta U < 0$, $W > 0$ → $Q < 0$

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34. B

Photoelectric effect ---- use the concept "photons", they 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" .

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35. E

Force $F = -\dfrac{dU}{dr}$

Positive force is repulsive, negative force is attraction

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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 diameter^2, so the error contributed by it is 3.2 %.

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37. E

(1) Steeper of the elastic region → Stiffer

(2) Higher peak of the plastic region → 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) Av = constant. AX = AZ > AY, so vX = vZ < vY

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

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39. C

Among the options, only red light has a frequency lower than yellow light.

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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	$21E_0/100$

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41. B

Output loop, 6V = I_C (2kΩ) + 2V ➔ I_C = 2 mA

I_B = 0.002/100 = 0.00002 A

Input loop, 6 V = (0.00002)R+0.6 ➔ R = 270 kΩ

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42. B

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

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

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43. B

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44. C

Binding energy per nucleon = (1.0078 + 1.0087 – 2.0146)931/2 = 0.88 MeV

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45. D

X: 480/119 = 2^n ➔ n = 2

Y: 135/9 = 2^n ➔ n = 3.9

Z: 168/93 = 2^n ➔ n = 0.85

Penentrative 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.