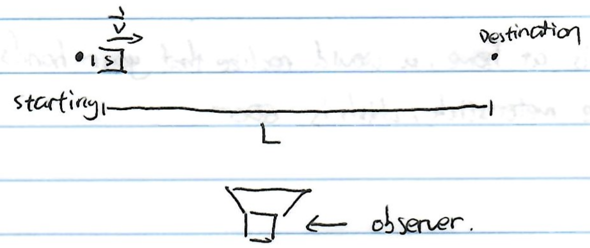
2017

1) C

By rubbing the comb, the comb will be charged, and since no operation has been done to the paper, we can assume that the paper has no "net charged." However, if the comb is positively charged, it attracts the negative charges in the paper, and vise versa.

2) C

other options ~~are~~ sound more absurd, However, considering a spaceship "S"



and we have the equations

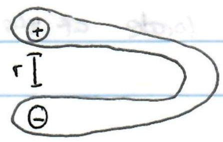
$$\Delta t = \frac{\Delta t_p}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$L_s = L_p\sqrt{1-\frac{v^2}{c^2}}$$

If "v" approches "c", it is likely that the spaceship travels a very short distance in a very high velocity, and the observer would observe a travel time longer than 2.5 million years but the travelers only get 15 years older.

3) B

assuming :



if r gets smaller, the electric field would increase, and it makes ~~eel~~ easier to stun the prey.

4) A

PS : This question mistakenly takes "power" as "Intensity; they are not the same thing.

$I = \frac{P}{2\pi r}$ in 2 dimention world

$$I = \frac{36}{2\pi(3)} \frac{W}{m}$$

$$= \frac{6}{\pi} \frac{W}{m}$$

5) E

$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{7}{10}mv^2$

$\frac{7}{10}mv^2 - Fd = \frac{1}{8}mv^2 + \frac{1}{5}(m)(\frac{v}{2})^2$

$\frac{28}{40}mv^2 - Fd = \frac{7}{40}mv^2$

$\frac{21}{40}mv^2 = Fd$

$\frac{7}{10}mv^2 - n \cdot \frac{21}{40}mv^2 = 0$

$n = \frac{4}{3}$

therefore, it takes $\frac{4}{3}d$ to stop the ball

6) D

If you try this at home, u would realize that your hands always meet at the center of mass of the meter stick, which is 50cm

7) D

$ma_c = \frac{GMm}{r^2}$

$a_c = \frac{GM}{r^2}$

$= \frac{1.99\times10^{30} \cdot (6.67\times10^{-11})}{(6.96\times10^{8})^2}$

$a_c \approx 250\ m/s^2$

8) D

According to Kepler's first law; the moon orbits around the planet in an elliptical shape, and the center of mass of the planet ~~is~~ always locate at the focal point. For option A, B, C they ~~don't~~ disobey this Law.

9) A

~~Lower~~ Higher energy => shorter wave length

and according to the equation $\Delta x = \frac{\lambda L}{d}$

the range of the maximum fringe is shorter ~~of~~.

10) B

The image shows a "fata magana" which is formed when a layer of hot air is above ~~a~~ layer of cold air

11) A

$$\lim_{t \to \infty} A(1-e^{-Bt}) = A$$

from the graph, it is obvious that the graph is approaching 20°C,

Therefore,

$$A = 20^\circ C$$

By plugging in number at $t = 1$

$$4 = 20(1 - e^{-B})$$

$$-\frac{4}{5} = -e^{-B}$$

$$\frac{4}{5} = \frac{1}{e^{B}}$$

$$e^{B} = \frac{5}{4}$$

$$B = \ln\frac{5}{4}$$

$$B = 0.223 \approx \frac{1}{5}$$

12)

what we need is to find the temperature when $r_{sphere} = r_{ring}$

$$r_s + \Delta r_s = r_r + \Delta r_r$$

$$10.005 + \Delta r_s = 10 + \Delta r_r$$

$$10.005 + 10.005(0.5 \times 10^{-5})\Delta T = 10 + 10 \cdot 10^{-5} \Delta T$$

$$\Delta T = 100.23^\circ C$$

$$100.23 + 20 \approx 120^\circ C$$

13) D

$$P \cdot A = F = m \cdot \vec{a} = \frac{I}{c} \cdot A$$

$$\Downarrow$$

$$(0.025 + 0.0001 \cdot A)(0.02) = \frac{1.38 \times 10^{3}}{3 \times 10^{8}} A$$

$$0.0005 + 0.000002 A = 0.000005 A$$

$$0.0005 = 0.000003 A$$

$$A = 166.7\ m^2 \quad \text{closest to } 200\ m^2$$

14) C

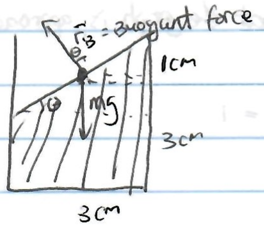
In the inertial frame of reference

$$\text{Work} = \vec{F} \cdot \vec{d}$$ therefore, it is reasonable to conjecture that

$$\text{Work rotation} = \vec{T} \cdot \vec{\theta}$$

15) B

right before the water spill :



$F_B \cos\theta = mg$
$F_B \sin\theta = ma$ } divide $\Rightarrow \tan\theta = \frac{a}{g} = \frac{2}{3}$

$\Downarrow$

$a = \frac{2}{3}g$

16) B

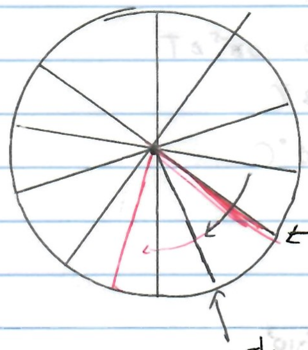
when the iron rod is inserted, the inductance and the inductive resistance increasings.
~~cur~~ - Therefore, the current decreases when the rod enters, and vice versa when the rod exits.

17) B

$\frac{dQ}{dt} = KA \frac{dT}{dx} \leftarrow$ slope

$\frac{dT}{dx} = \frac{1}{KA}\frac{dQ}{dt} \Rightarrow \frac{dT}{dx} \propto \frac{1}{A} \longrightarrow B$

18) D



$2\,rev/s = 4\pi\,rad/s$

$\frac{4\pi}{15} = \frac{4\pi}{15}\frac{rad}{\frac{1}{15}s}$

← considering this red line

when $t = \frac{1}{15}$

The camera would think this black line is the original red line,
therefore the rotational speed is ~~12~~ 12° = 0.5 rev/s

19) C

$\rho g h = P$ and since water can compress, which means P will increase as the depth increases,

Therefore, C

20) D

several cases you have to memorize:

when

$m_1 < m_2$ $\quad$ $m_1 = m_2$ $\quad$ $m_1 > m_2$

after

21) D

$\vec{v} = v_i - \frac{F_f}{m} t$

$\vec{\omega} = \frac{F_f R}{I} \cdot t$

$mv = M v_i$

$v_i = \frac{mv}{M}$

rolling occurs when $\vec{v} = \vec{\omega} r$

$(v_i - v) = \frac{F_f}{m} \cdot t$

$(m v_i - m v) = F_f \cdot t$

$\Downarrow$

$\vec{\omega} = \frac{MR}{I} \cdot \cancel{t} \cdot (v_i - v) \qquad \vec{\omega} = \frac{\vec{v}}{r}$

$\vec{v} = \frac{MR^2}{I} \cdot (v_i - v)$

$\vec{v}\left(1 + \frac{MR^2}{I}\right) = v_i \cdot \frac{MR^2}{I}$

$\vec{v} = \frac{v_i \frac{MR^2}{I}}{1 + \frac{MR^2}{I}}$

$= \frac{v_i \cdot \frac{5}{2}}{1 + \frac{5}{2}}$

$= \frac{\frac{5}{2} v_i}{\frac{7}{2}}$

$\vec{v} = \frac{5}{7} v_i$

$\vec{v} = \frac{5}{7}\left(\frac{mv}{M}\right)$

$= \frac{5}{7}\left(\frac{0.005}{2.005} \cdot 1000\right)$

$= 1.781 \text{ m/s}$

22) E

$L = L_0\sqrt{1-\frac{v^2}{c^2}}$

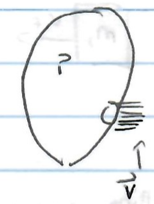
$L_A = L\sqrt{1-\frac{v^2}{c^2}}$ from the frame of reference of the observer stationary to B

$L_A = \frac{4}{5}L$ $\frac{L_A}{L_B} = \frac{16}{25}$

$L_B = \frac{5}{4}L$

23) A a little bit counter intuitive

Assuming



Bernoulli equation:

$P = P_{atm} + \frac{1}{2}\rho v^2$

$P > P_{atm}$

Therefore, all air particles have a velocity $\vec{v}$

Then,

$\frac{1}{2}m\vec{v}^2 = \frac{3}{2}k_B T$

which means particles with velocity outside of the balloon have a higher temperature than T.

24) A

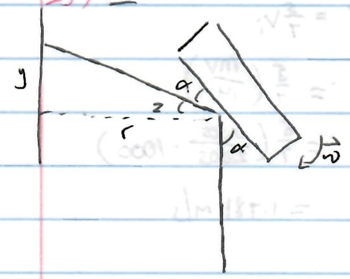
By the right-hand rule, the field must be directed into the page

and

$mg = \vec{B} I \vec{l}$

$\vec{B} = \frac{mg}{Il}$

25) E



$\alpha = \theta - \omega t$

$\begin{cases} 2(\theta - \omega t) + 2z = 90^\circ \xrightarrow{\text{derivative}} -2\omega + \frac{dz}{dt} = 0 \\ \tan z = \frac{y}{x} \Rightarrow z = \frac{y}{x} \end{cases}$

$\frac{dz}{dt} = 2\omega$

small-angle approximation

$\frac{dz}{dt} = \frac{1}{x}\frac{dy}{dt}$

$2\omega = \frac{1}{r}\frac{dy}{dt}$

$2\omega r = \frac{dy}{dt}$