FIRST YEAR SECOND TERMINAL EXAM - DECEMBER 2025

HSE I

PHYSICS

① a) 4 (b) 5

② a) Constant acceleration

(3) c) - z direction

4) b) Zero

5) d) Forces acting on particle

6) a) $K_A > K_B > K_C$

7) b) Angle of contact

II Any 5 (8-14)

8) a) Average acc^n

Ratio of total change in velocity to the total time

$$\bar{a} = \frac{\Delta V}{\Delta t}.$$

b) Instantaneous acc^n

Acc^n at any instant of time

$$a = \lim_{\Delta t \to 0}\left(\frac{\Delta v}{\Delta t}\right) = \frac{dv}{dt}$$

9) tangent.

when the string is released, there is no force, the body will move in a straight line with constant velocity, along the tangent.

10) a) It is the collision in which Kinetic energy is not conserved, but linear momentum conserved

b) For elastic collision, KE also conserved.

11) $\vec{L} = \vec{r} \times \vec{p}$

$$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{p})$$

$$= \vec{r} \times \frac{d\vec{p}}{dt} + \frac{d\vec{r}}{dt} \times \vec{p}$$

$$= \vec{r} \times \vec{F} + \vec{v} \times m\vec{v}$$

$$= \vec{\tau} + 0$$

$$\boxed{\frac{dL}{dt} = \vec{\tau}}$$

(12) a) $g = \frac{GM}{R^2}$

b) (ii) $M' \to 2M$

$R' \to 2R$

$$g' = \frac{GM'}{(R')^2} = \frac{G \times 2M}{(2R)^2} = \frac{2GM}{4R^2}$$

$$= \frac{1}{2} g$$

(13) a) For steady flow of fluid through a pipe,

aV = constant

OR

$a_1V_1 = a_2V_2$

b) (ii) $V_A < V_B$

14) b) 1 OR 100%

a) Energy radiated per unit area per unit time is directly proportional to fourth power of absolute temp(T)

Emissive power, $E \propto T^4$

(15) $\nu \propto F^a l^b \mu^c$ —①

$[\nu] = [M^0L^0T^{-1}]$ —②

$[F] = [MLT^{-2}]$

$[l] = [L]$

$[\mu] = [ML^{-1}]$

$[F^a l^b \mu^c] = (MLT^{-2})^a L^b (ML^{-1})^c$

$= [M^{a+c} L^{a+b-c} T^{-2a}]$ —(3)

(2) and (3) $\Rightarrow$

$a + c = 0$

$a + b - c = 0$

$-2a = -1$

$a = \frac{1}{2}$

$\frac{1}{2} + c = 0$

$c = -\frac{1}{2}$

$\frac{1}{2} + b - \left(-\frac{1}{2}\right) = 0$

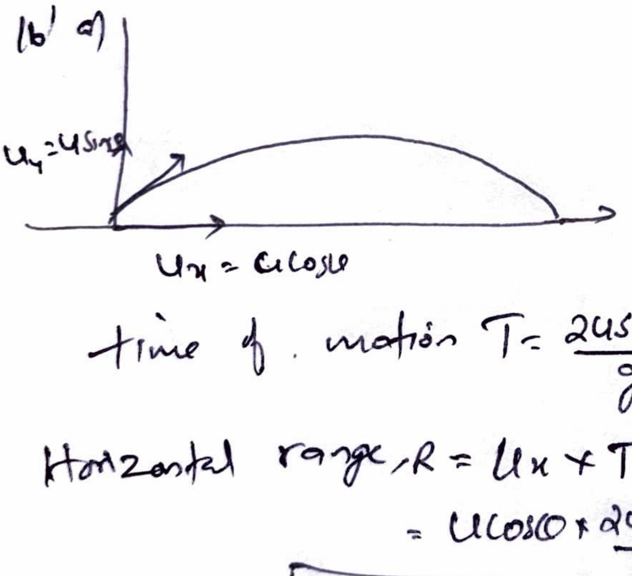
$1 + b = 0$

$b = -1$

(1) $\Rightarrow \nu \propto F^{1/2} l^{-1} \mu^{-1/2}$

$\propto \frac{1}{l}\frac{\sqrt{F}}{\sqrt{\mu}}$

16) a)



time of motion $T = \frac{2u\sin\theta}{g}$

Horizontal range, $R = u_x \times T$

$= u\cos\theta \times \frac{2u\sin\theta}{g}$

$\boxed{R = \frac{u^2 \sin 2\theta}{g}}$

b) $R_{30} = R_{60}$ (if $u_{30} = u_{60}$)

17) Displacement

If $F_{ext} = 0$, P = Constant

b) $mv = -MV$

$V = -\frac{mv}{M}$

Recoil speed

$|V| = \frac{0.020 \times 80}{100} = 0.016$ m/s.

18) a) (i) pure rotation

b) For rotational equilibrium

clockwise Torque = Anticlockwise torque

$F_2 \times d_2 \sin 90 = F_1 \times d_1 \sin 90$

$\boxed{F_1 d_1 = F_2 d_2}$

19) statement of pascals law

pascals law $\Rightarrow$

$P_1 = P_2$

$= \frac{F_2}{A_2}$

$A_2 = 425\,cm^2 = 425 \times 10^{-4}\,m^2$

$= \frac{M_2 g}{A_2}$

$= \frac{3000 \times 9.8}{425 \times 10^{-4}}$

$= 69.18 \times 10^4$ Pa

20) a) $\alpha_V = \frac{\Delta V}{V \Delta T}$

It is the change in volume per unit original volume per unit change in temperature.

b) consider a cube of side l.

Volume $V = l^3$

For a change in temp: ΔT,

New volume,

$V' = V + \Delta V = (l + \Delta l)^3$

$\cancel{V} + \Delta V = \cancel{l^3} + 3l^2\Delta l + 3l\Delta l^2 + \Delta l^3$

$\Delta V \approx 3l^2 \Delta l$

$3l\Delta l^2$ and Δl^3 are negligible

$$\frac{\Delta V}{V} = \frac{3l^2 \Delta l}{V} = \frac{3l^2 \Delta l}{l^3}$$

$$= \frac{3\Delta l}{l}$$

$$\therefore \alpha_V = \frac{\Delta V}{V\Delta T} = \frac{3\Delta l}{l \Delta T} = 3\alpha_l$$

21) First law of Thermodynamics

$$\Delta Q = \Delta U + P\Delta V$$

At constant volume,

$$C_V = \left(\frac{\Delta Q}{\Delta T}\right)_V = \left(\frac{\Delta U}{\Delta T}\right)_V + 0$$

At constant pressure

$$C_p = \left(\frac{\Delta Q}{\Delta T}\right)_p = \left(\frac{\Delta U}{\Delta T}\right)_p + \frac{P\Delta V}{\Delta T}$$

But $\left(\frac{\Delta U}{\Delta T}\right)_V = \left(\frac{\Delta U}{\Delta T}\right)_p = C_V$

$$\therefore C_p = C_V + \frac{P\Delta V}{\Delta T} \quad \text{—— (1)}$$

for 1 mole,

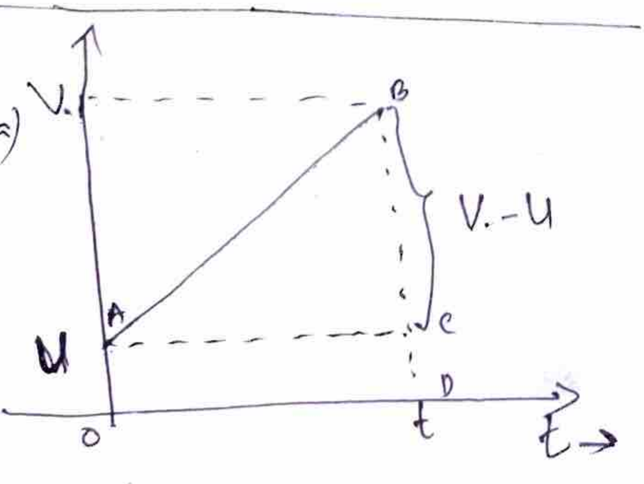
$PV = RT \qquad P\Delta V = R\Delta T$

$$\frac{P\Delta V}{\Delta T} = R$$

$$\therefore (1) \Rightarrow \boxed{C_p = C_V + R}$$

Another relation is $\frac{C_p}{C_V} = \gamma$

22) a)



Displacement = Area under v-t graph

S = Area OACD + Area ABC

$= u \times t + \frac{1}{2} \times t \times (v-u)$

$= ut + \frac{1}{2} t \times at$

$$\boxed{S = ut + \frac{1}{2}at^2}$$

b) Displacement = Area

$= \left(\frac{1}{2} \times 1.5 \times -2\right) + \left(\frac{1}{2} \times 1 \times \cancel{0.5}\right) + 1 \times (5-2)$

$= -1.5 + 0.25 + 3$

$= 1.75$ m

Distance = |Area|

$= 1.5 + 0.25 + 3$

$= 4.75$ m

23) a) Work is said to be done by a force if the point of application displaces ~~from~~ in the direction of the force

$$W = \vec{F} \cdot \vec{S}$$

b) False (can be zero in the case of static friction, −ve in the case of kinetic friction)

c) $W = F \times S$

$= 30 \times 10$

$= 300$ J

24) a) According to Hooke's law, within proportional limit
Linear stress $\propto$ linear strain

$$\frac{F}{A} \propto \frac{\Delta l}{l}$$

$$\frac{F}{A} = Y\frac{\Delta l}{l}$$

$$Y = \frac{Fl}{A\Delta l}$$

b) $F = mg$
$= 4.8 \times 10 = 48N$
$l = 2m$
$A = 0.2\ cm^2$
$= 0.2 \times 10^{-4}\ m^2$
$\Delta l = ?$
$Y = 2 \times 10^{11}$

$$Y = \frac{Fl}{A\Delta l} = \frac{mgl}{A\Delta l}$$

$$\Delta l = \frac{mgl}{AY} = \frac{48 \times 2}{0.2 \times 10^{-4} \times 2 \times 10^{11}}$$

$$= 240 \times 10^{-7}\ m$$

25) a) (ii) do +ve work
b) $dw = PdV$

$$W = \int_{V_1}^{V_2} PdV \quad \text{—①}$$

Isolthermal process, $PV = \mu RT$
or $P_1V_1 = P_2V_2$

$$W = \int_{V_1}^{V_2} \frac{\mu RT}{V} dV$$

$$= \mu RT \left(\log_e V\right)_{V_1}^{V_2}$$

$$= \mu RT(\log_e V_2 - \log_e V_1)$$

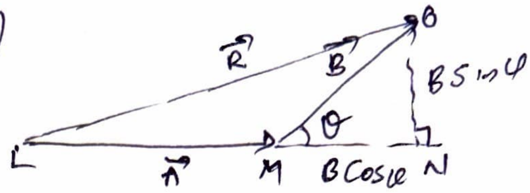
$$\boxed{W = \mu RT \log\left(\frac{V_2}{V_1}\right)}$$

OR

$$W = \mu RT \log_e\left(\frac{P_1}{P_2}\right)$$

V Any 3 (26-29)

26) a)



$\vec{R} = \vec{A} + \vec{B}$
$R^2 = LN^2 + NO^2$
$= (LM + MN)^2 + NO^2$
$= (A + B\cos\theta)^2 + (B\sin\theta)^2$
$= A^2 + 2AB\cos\theta + B^2\cos^2\theta + B^2\sin^2\theta$
$R^2 = A^2 + 2AB\cos\theta + B^2$

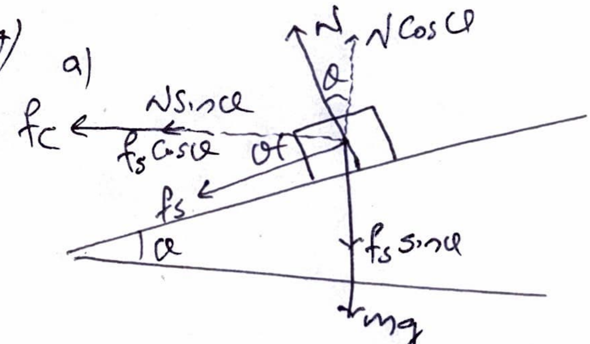
$\cos\theta = \frac{MN}{B}$
$\sin\theta = \frac{NO}{B}$

$$\boxed{R = \sqrt{A^2 + B^2 + 2AB\cos\theta}}$$

$\cos 60 = \frac{1}{2}$

b) $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$
$= \sqrt{5^2 + 7^2 + 2 \times 5 \times 7 \times \cos 60}$
$= \sqrt{25 + 49 + 35}$
$= 10.44$ unit

27) a)



b) $f_c = \frac{mv^2}{r} = f_s\cos\theta + N\sin\theta$ —①

At equilibrium,
$mg + f_s\sin\theta = N\cos\theta$
$mg = N\cos\theta - f_s\sin\theta$ —②

$$\frac{①}{②} \Rightarrow \frac{v^2}{rg} = \frac{f_s\cos\theta + N\sin\theta}{N\cos\theta - f_s\sin\theta}$$

For max safespeed

$$\frac{V_{max}^2}{rg} = \frac{f_{ms}\cos\theta + N\sin\theta}{N\cos\theta - f_{ms}\sin\theta}$$

$\div$ ing Nr and Dr of RHS by $N\cos\alpha$

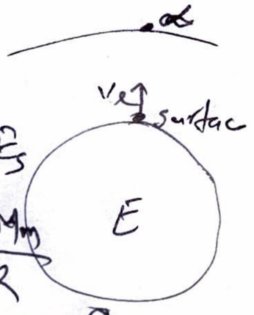
$$\frac{V_{max}^2}{rg} = \frac{\left(\frac{f_{ms}\cos\varphi}{N\cos\varphi} + \frac{N\sin\varphi}{N\cos\varphi}\right)}{\left(\frac{N\cos\varphi}{N\cos\varphi} - \frac{f_{ms}\sin\varphi}{N\cos\varphi}\right)}$$

But $\frac{f_{ms}}{N} = \mu$, coeff: of friction

$$\frac{V_{max}^2}{rg} = \frac{\mu + \tan\varphi}{1 - \mu\tan\varphi}$$

$$V_{max} = \sqrt{rg\left[\frac{\mu + \tan\varphi}{1 - \mu\tan\varphi}\right]}$$

28) a) It is the minimum velocity of projection so that a body escape from gravitational pull of the earth

b) 

$$TE_{surface} = KE_s + PE_s$$

$$= \frac{1}{2}mV_e^2 + \frac{-GMm}{R} \quad \text{---(1)}$$

$$TE_{\infty} = KE_{\infty} + PE_{\infty}$$

$$= 0 + 0 = 0$$

According to law of Conservation of mechanical energy,

$$TE_{surface} = TE_{\infty}$$

$$\frac{1}{2}mV_e^2 + \frac{-GMm}{R} = 0$$

$$\frac{V_e^2}{2} = \frac{GM}{R}$$

$$V_e = \sqrt{\frac{2GM}{R}}$$

c) $V_e = \sqrt{\frac{2GM}{R}}$

$$= \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.4 \times 10^{22}}{1740 \times 10^3}}$$

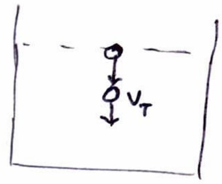
$$= \sqrt{0.0567 \times 10^8}$$

$$= 0.2381 \times 10^4$$

$$= 2381\, m/s$$

$$= 2.381\, km/s$$

29) Forces acting on a sphere moving down through a viscous liquid are



a) weight, $F_1 = m_s g = V_s \rho g$

$$= \frac{4}{3}\pi a^3 \rho g \downarrow \text{---(1)}$$

b) Viscous drag, $F_2 = 6\pi a \eta V \uparrow$ ---(2)

(c) Bouyant force $F_3 = m_l g$

$$= V_l \sigma g$$

$$= \frac{4}{3}\pi a^3 \sigma g \uparrow \text{---(3)}$$

At equilibrium, Net force becomes zero and velocity becomes constant, called terminal velocity (V_T)

Now,

$$F\uparrow = F\downarrow$$

$$\frac{4}{3}\pi a^3 \sigma g + 6\pi a \eta V_T = \frac{4}{3}\pi a^3 \rho g$$

$$6\pi a \eta V_T = \frac{4}{3}\pi a^3(\rho - \sigma)g$$

$$\boxed{V_T = \frac{2}{9\eta}a^2(\rho - \sigma)g}$$

b) $\eta = \frac{2}{9V_T}a^2(\rho - \sigma)g$

$$= \frac{2 \times (2 \times 10^{-3})^2 (8.9 - 1.5) \times 10^3 \times 9.8}{9 \times 6.5 \times 10^{-2}}$$

$$= \frac{2 \times 4 \times 7.4 \times 9.8}{9 \times 6.5} \times \frac{10^{-3}}{10^{-2}}$$

$$= 0.992\ Pas \quad \text{OR } 0.992\ Pl$$

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