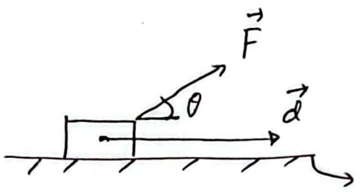
Chapter 7 and 8

"Kinetic Energy and Work"

and

"Potential Energy and Conservation of Energy"

Work:



Work done by Force, $W = \vec{F}\cdot\vec{d}$

$= F d \cos\theta$

$= F (d\cos\theta)$

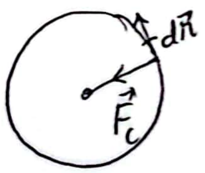
= (Force) × (component of displacement along the direction of $\vec{F}$)

$= (F\cos\theta)\times d$

= (Component of $\vec{F}$ along the direction of $\vec{d}$) × (displacement)

(i) Work done by Force, ⇒ zero if $|\vec{d}| = 0$ or $\vec{F} \wedge \vec{d} = 90°$

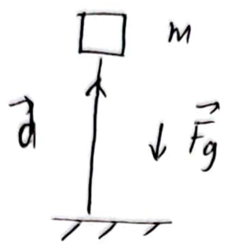
Example: In Uniform circular work done by centripetal Force is zero.



$\vec{F_c} \wedge d\vec{r} = 90°$

$W = \int \vec{F_c}\cdot d\vec{r} = 0$

(ii) Work done by force => negative : if $90^\circ < \vec{F} \wedge \vec{d} \leq 180^\circ$

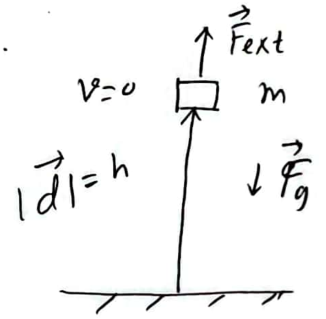


Here work done by $\vec{F_g}$ is negative.

(iii) Work done by Force => positive : if $0 \leq \vec{F} \wedge \vec{d} \leq 90^\circ$

Work done by Constant Force:

Considering here, $\vec{F} \wedge \vec{d}$ = constant. For instance, consider in the figure.



Here, $\vec{F_g} \wedge \vec{d} = 180^\circ$
and $\vec{F}_{ext} \wedge \vec{d} = 0^\circ$

Work done by gravitational Force,

$$W_g = \vec{F_g} \cdot \vec{d}$$
$$= |\vec{F_g}||\vec{d}| \cos 180^\circ$$
$$= -mgh$$

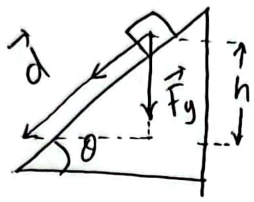
Work done by external Force, $W_{ext} = \vec{F}_{ext} \cdot \vec{d}$

$$= |\vec{F}_{ext}| |\vec{d}| \cos 0^\circ$$
$$= mgh$$
$$= -W_g$$

$\therefore$ Work done by net Force, $W_{net} = W_g + W_{ext} = 0$.

Consider a Frictionless ramp. If the block slide down d distance along the surface of the ramp. Then work done by gravitational Force,

$$W_g = \vec{F}_g \cdot \vec{d}$$

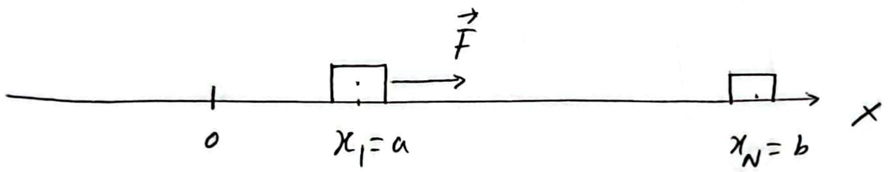


$$= |\vec{F}_g||\vec{d}| \cos(90^\circ - \theta)$$

$$= mg\, d \sin\theta \quad , \text{ but } \sin\theta = \frac{d}{h}$$

$$= \boxed{mgh}$$

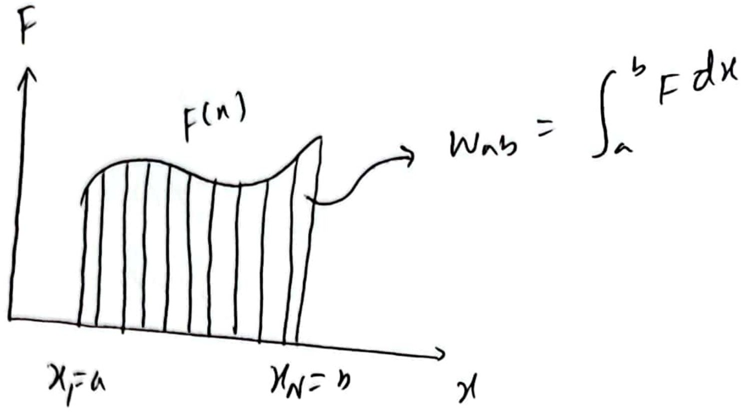
$\boxed{\text{Work done by variable Force}}$ (1D)



Consider a particle is confined along x-axis. This time applied Force may be variable with respect to position x. For simplicity the angle between the force and displacement is always constant ($= 0^\circ$). If the particle is moved from $x_1 = a$ to $x_N = b$ upon by applied variable force $F(x)$, then the work done by variable Force will be,

$$W_{ab} = F(x_1)\Delta x + F(x_2)\Delta x + \cdots + F(x_{N-1})\Delta x$$

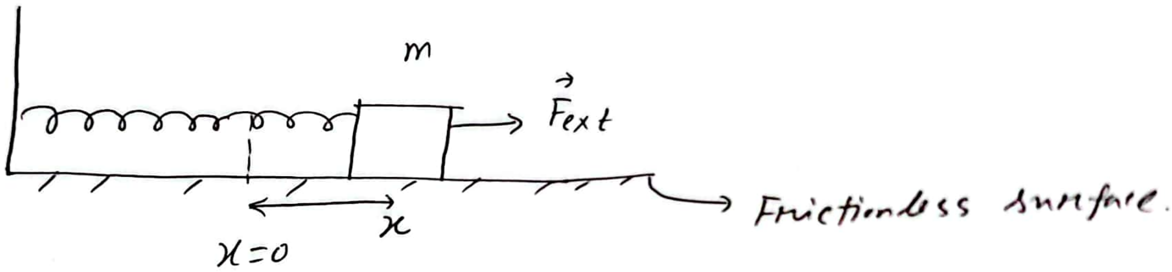
$$= \sum_{i=1}^{N} F(x_i)\Delta x \quad \text{—(1)}$$



If $N \to \infty$, then $\Delta x \to dx$ so the eqn (1) can be written as,

$$W_{ab} = \int_a^b F(x)\,dx$$

Work done by spring Force:



According to Hooke's Law, spring Force,

$$F_s \propto -x$$

$$\Rightarrow F_s = -kx$$

where k is spring constant.

So, Here the force is variable. Work done (From x_i to x_f) done by spring Force can be

$$W^s_{i \to f} = \int_{x_i}^{x_f} F_s\,dx = \int_{x_i}^{x_f} (-kx)\,dx$$

$$W^{s}_{i\to f} = -\left[\frac{1}{2}kx^2\right]_{x_i}^{x_f}$$

$$= \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

Work done by external Force,

$$W^{ext}_{i\to f} = -W^{s}_{i\to f}$$

$$= \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2$$

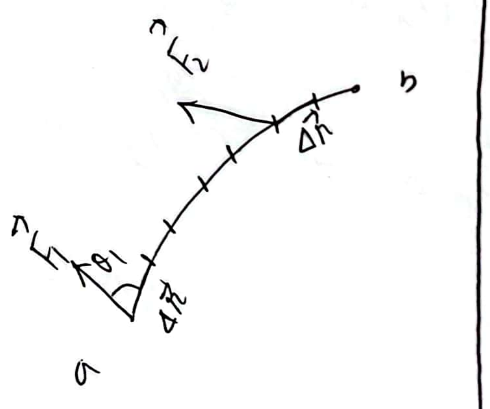
If $x_i = 0$ (equilibrium position) and $x_f = x$

then, Work done by external force here,

$$\boxed{W^{ext} = \frac{1}{2}kx^2}$$

Work done by variable Force : (2D or 3D)

Consider a particle is moving ~~fore~~ from a to b under variable force $\vec{F}$.



This time the path is curved (2D) and the angle between $\vec{F}$ and $\Delta\vec{r}$ is not always constant. To find the work done by variable Force $\vec{F}$ upon transition the particle from a to b can be obtained by dividing the path into n equal $\Delta\vec{r}$ intervals.

The work done by $\vec{F}$, can be written as,

$$W_{ab} = W_1 + W_2 + \dots + W_n$$

$$= \vec{F}_1 \cdot \Delta\vec{r} + \vec{F}_2 \cdot \Delta\vec{r} + \dots + \vec{F}_N \cdot \Delta\vec{r} = \sum_{i=1}^{N} \vec{F}_i \cdot \Delta\vec{r}$$

If $n \to \infty$, then $\Delta\vec{r} \simeq d\vec{r}$, so we can write down,

$$W_{ab} = \int_a^b \vec{F} \cdot d\vec{r} \quad \text{——(1)}$$

But this integral can't be performed only because of the angle bet^n the force and displacement always changing.

To perform this Integral we have to,

$$\vec{F} = F_x \hat{i} + F_y \hat{j}, \quad \text{and} \quad \vec{r} = x\hat{i} + y\hat{j}$$

$$d\vec{r} = dx\,\hat{i} + dy\,\hat{j}$$

So the eq^n (1) can be written as,

$$W_{ab} = \int_a^b [(F_x\,dx) + (F_y\,dy)]$$

$$W_{ab} = \int_{x_a}^{x_b} F_x\,dx + \int_{y_a}^{y_b} F_y\,dy \quad \text{——(2)}$$

Equation (2) is so-called line integral.

For 3D, $W_{ab} = \int_{x_a}^{x_b} F_x\, dx + \int_{y_a}^{y_b} F_y\, dy + \int_{z_a}^{z_b} F_z\, dz$

$\boxed{**}$ Sample problem : 7.08

Applied Force, $\vec{F} = (3x^2 N\hat{i} + 4N\hat{j})$. The particle moves from (2m, 3m) to (3m, 0m).

$W_{ab} = ?$

$$W_{ab} = \int_{x_a}^{x_b} F_x\, dx + \int_{y_a}^{y_b} F_y\, dy$$

$$= \int_2^3 3x^2\, dx + \int_3^0 4\, dy$$

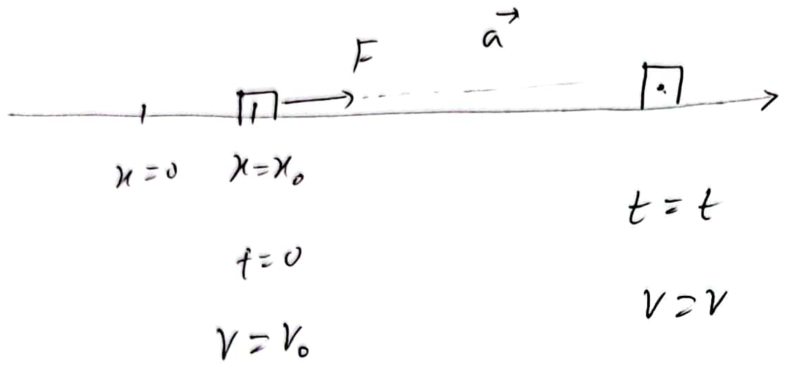
$$= ([x^3]_2^3 + 4 \cdot [y]_3^0)\, J$$

$$= [(27-8) + 4(-3)]\, J$$

$$= (19 - 12)\, J$$

$$= \boxed{7\, J}$$

Work – Kinetic Energy Theorem:



Work done by Force,

$$W = \int_{x_0}^{x} F\,dx$$

$$= \int_{x_0}^{x} ma\,dx \qquad \left[\text{From Newton's } 2^{nd} \text{ law, } F = ma\right]$$

Now, $a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = \frac{dv}{dx}v = v\frac{dv}{dx}$

x	x_0	x
v	v_0	v

So, $W = m\int_{v_0}^{v} v\frac{dv}{dx}\,dx$

$$= m\int_{v_0}^{v} v\,dv$$

$$= m\left[\frac{v^2}{2}\right]_{v_0}^{v}$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

$$= K - K_0 \qquad \text{kinetic energy, } K = \frac{1}{2}mv^2$$

$\boxed{\text{Work-Energy theorem}} \rightarrow \boxed{W = \Delta K}$; $\boxed{\text{unit} \rightarrow J}$

Power : → Work done by force in per unit time.

Average power, $P_{avg} = \frac{W}{\Delta t}$; Δt = time interval

Instantaneous power, $P = \frac{dW}{dt}$

$$= \frac{d}{dt}(\vec{F} \cdot d\vec{r})$$

$$= \vec{F} \cdot \frac{d\vec{r}}{dt}$$

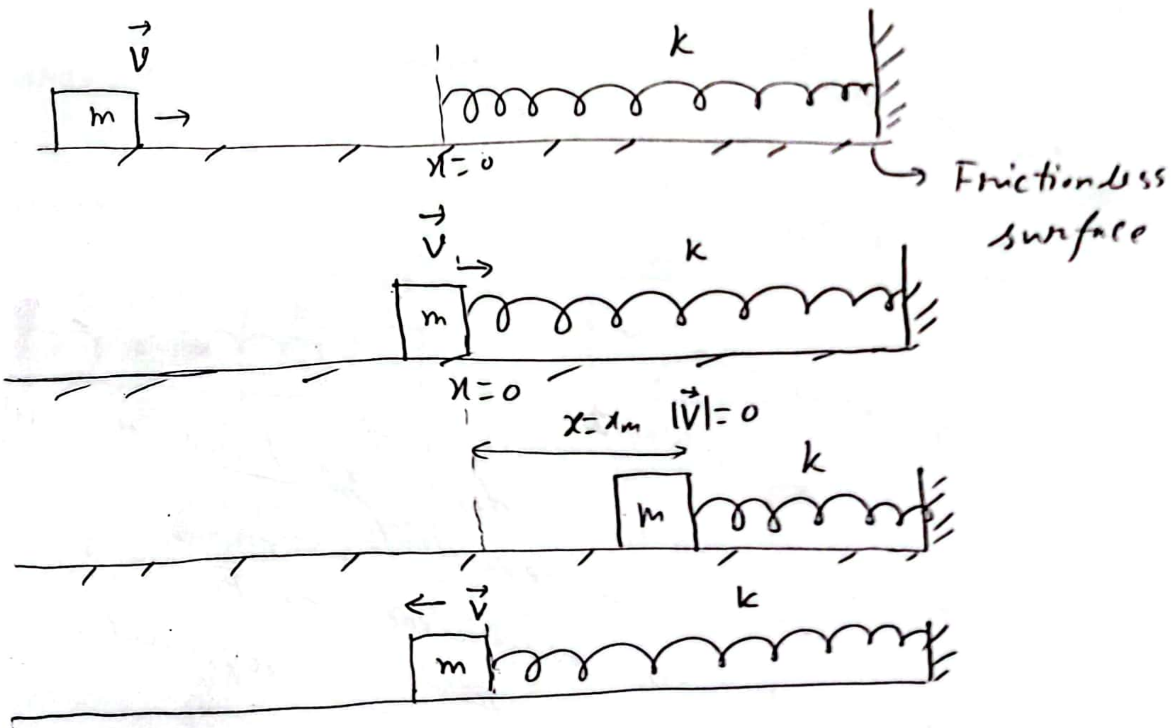
$$= \vec{F} \cdot \vec{v}$$

1 watt = 1 J s^{-1}

1 kW-h = $10^3 \times 1\, J s^{-1} \times 3600\, s = 3.6 \times 10^6\, J$

1 HP = 746 W

Conservative Force:



After a round trip, workdone by Force,

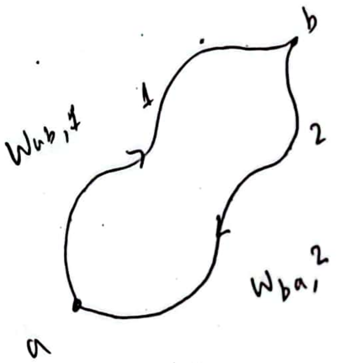
$$W = \Delta k = \frac{1}{2}mv^2 - \frac{1}{2}mv$$
$$= 0$$

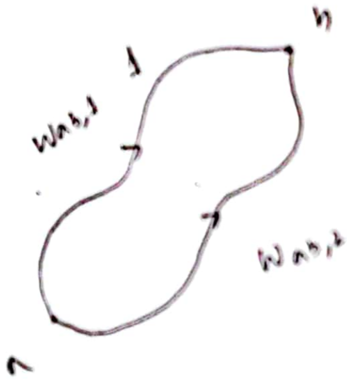
Conservative Force :

→ Work done by Force on a particle after a round trip is zero.

Nonconservative Force :

→ Work don by Force on a particle after a round trip is not zero



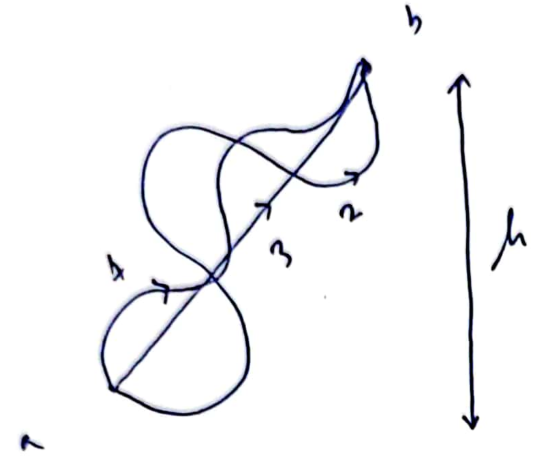


$$W_{ab,1} + W_{ba,2} = 0$$

$$\Rightarrow W_{ab,1} = -W_{ba,2}$$
$$= W_{ab,2}$$

Conservative Force : → Work done by Force is path independent.

Non-Conservative " : → work done by Force is path ~~dep~~ dependent



$W_{ab,1} = W_{ab,2} = W_{ab,3} = mgh$

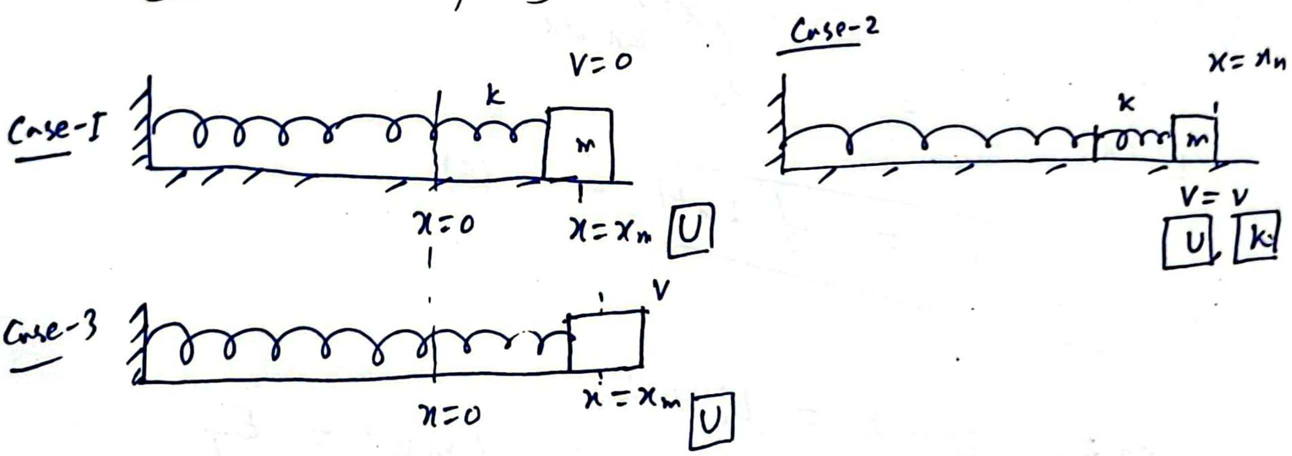
Examples of conservative Force: Spring Force,
Gravitational Force,
Electrostatic Force etc.

Examples of Non-conservative Force: Friction

Potential Energy: * There is no general formula for potential Energy.

Energy of configuration → Potententia Energy.

Consider a spring-block system



$$\Delta U + \Delta k = 0 \quad \text{---(1)}$$

Integrating this eqn: $U + k = \text{Const} = E_{TOT}$ ---(2)

Mechanical Energy

Partic

From equation (1),

$$\Delta U = -\Delta k$$

$$= -W$$

$$\Rightarrow \Delta U = -\int_0^x F(x)\,dx \quad \cdots \quad (3)$$

Integrating this equation: $\frac{dU}{dx} = -F(x)$ --- (4)

(In 3D) $\vec{F} = -\vec{\nabla} U$ --- (5)

For spring-block system:

$$\Delta U = -\int_{x=0}^{x=x} F(x)\,dx$$

$$\Rightarrow U(x) - U(0) = -\int_{x=0}^{x=x} -kx\,dx$$

$$\Rightarrow U(x) = \int_0^{x=x} kx\,dx$$

$$\therefore \boxed{U(x) = \frac{1}{2}kx^2} \quad \cdots \quad (6)$$

From eqn (2), $U + k = U_0 + k_0$

$$\Rightarrow \frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kx_0^2 + \frac{1}{2}mv_0^2 = E_T$$

Particle - Earth System:

$y_2 = y\ ;\ U(y_2) = ?$

$y_1 = 0\ ;\ U(y_1) = 0$

$$\Delta U = -\int_{y_1}^{y_2} F_y\, dy$$

$$= -\int_{y_1}^{y_2} (-mg)\, dy$$

$$= mg\ [y]_{y_1}^{y_2}$$

$$\Delta U = mg\,(y_2 - y_1) \quad \text{—(1)}$$

$$= mg\,\Delta y$$

setting, $y_1 = 0$, $y_2 = y$, $U(y_1) = 0$, $U(y) = ?$

Eqn: (1) $\Rightarrow$

$$U(y) - U(y_1) = mg\,(y - 0)$$

$$\Rightarrow \quad U(y) = mgy \quad \ldots (2)$$

Problems → [Ch - 7 and 8]

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

$W_{net} = \int_{x=a}^{x=b} F(x)\, dx$

$W_{net} = \int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \cdot d\vec{r}$

$$= \int_{x_i}^{x_f} F_x\, dx + \int_{y_i}^{y_f} F_y\, dy$$

Kinetic Energy, $K = \frac{1}{2} m v^2$

Work - Kinetic Energy Theorem: $W = \Delta K = K_f - K_i$

Power, $P = \frac{dW}{dt} = \frac{\vec{F} \cdot d\vec{r}}{dt} = \vec{F} \cdot \vec{v}$

Conservative Force, $F(x) = -\frac{dU}{dx}$ (1D)

∴ Potential Energy is function of position (For conservative system)

For conservative system, $\Delta K + \Delta U = 0 \Rightarrow U + K = E_{TOT}$

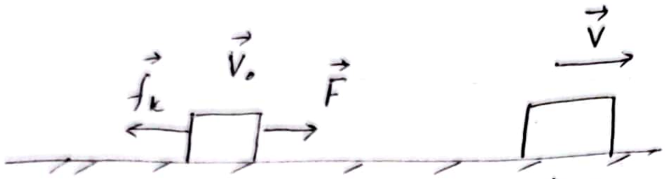
$$\Delta U = -\int_{x_1}^{x_2} F(x)\, dx$$

Conservation of Energy,

$$E_{mec} = K_i + U_i = K_f + U_f$$

Particle - Earth system, Potential Energy, $U(y) = mgy$

Spring - block " , Potential Energy, $U(x) = \frac{1}{2} k x^2$



$\vec{F}_{net} = \vec{F} - \vec{f_k}$

For (1D), $F - f_k = ma$

$$v^2 = v_0^2 + 2ad$$

$$\Rightarrow \frac{v^2 - v_0^2}{2} = ad$$

$$\Rightarrow \frac{1}{2} m v^2 - \frac{1}{2} m v_0^2 = mad$$

$$\Rightarrow \Delta k = (F - f_k) d$$

$$\Rightarrow \Delta k = Fd - f_k d$$

$$\Rightarrow \Delta k + f_k d = Fd$$

$$\Rightarrow Fd = \Delta k + f_k d$$

$$\therefore \boxed{W = \Delta k + \Delta E_{th}}$$

$\Delta E_{th} = f_k d$ = Thermal Energy (produced by friction)

In General : $W = \Delta E_{mec} + \Delta E_{th}$

* Ch-7: SP- 7.01 – 7.06, 7.08

CP – 1–3

Pr – 1, 11*, 15, 19, 24*, 61

* Ch-8 : SP- 8.01– 8.06

CP – 1–4

Pr – 6*, 22*, 29, 48, 53*, 57*, 62

Ch-7

11

$|\vec{F}| = 12\,N$

$\vec{d} = (2\hat{i} - 4\hat{j} + 3\hat{k})\ m$

$|\vec{d}| = \sqrt{(2)^2 + (-4)^2 + (3)^2}\ m$

$= 5.39\ m$

(a) when $\Delta k = 30\,J$, $\theta = ?$

(b) when $\Delta k = -30\,J$, $\theta = ?$

(a) According to Work-kinetic Energy theorem,

$$W = \Delta k$$

$$\Rightarrow \vec{F} \cdot \vec{d} = \Delta k$$

$$\Rightarrow |\vec{F}|\,|\vec{d}| \cos\theta = 30$$

$$\Rightarrow 12 \times 5.39 \cos\theta = 30$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{30}{12 \times 5.39}\right) = \boxed{62.37^\circ}$$

(b) $W = \Delta k$

$$\Rightarrow \vec{F} \cdot \vec{d} = \Delta k \Rightarrow |\vec{F}|\,|\vec{d}| \cos\theta = \Delta k$$

$$\Rightarrow \cos\theta = \frac{\Delta k}{|\vec{F}|\,|\vec{d}|}$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{-30}{12 \times 5.39}\right) = \boxed{117.63^\circ}$$

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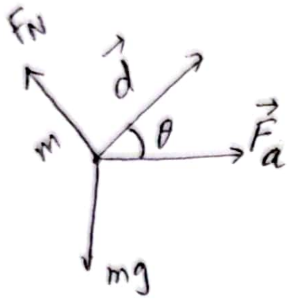

$|\vec{F}_a| = 20N$

$m = 3\,kg$

$|\vec{d}| = 0.5\,m$

$\theta = 30^\circ$

$W = ?$

(a)

Work done by $\vec{F}_a$, $W_a = \vec{F}_a \cdot \vec{d}$

$= |\vec{F}_a|\,|\vec{d}| \cos\theta$

$= (20)(0.5)\cos(30^\circ)\,J$

$= \boxed{8.66\,J}$

Work done by $\vec{F}_g$, $W_g = \vec{F}_g \cdot \vec{d}$

$= |\vec{F}_g|\,|\vec{d}| \cos(90^\circ + \theta)$

$= -mg\,d\,\sin\theta$

$= -3 \times 9.8 \times 0.5 \times \sin(30^\circ)\,J$

$= \boxed{-7.35\,J}$

Work done by $\vec{F}_N$, $W_N = \vec{F}_N \cdot \vec{d}$

$= |\vec{F}_N|\,|\vec{d}| \cos 90^\circ = \boxed{0\,J}$

Net work done by all Forces,

$W = W_a + W_g + W_N$

$= (8.66 - 7.35 + 0)\,J$

$= \boxed{1.31\,J}$ $\boxed{\text{Ans}}$

b

Initial kinetic Energy, $K_i = 0$

Final " " , $K_f = \frac{1}{2} m v_f^2$

According to work-kinetic energy theorem,

$$W = \Delta K$$

$$\Rightarrow 1.31 = \frac{1}{2} m v_f^2 - 0$$

$$\Rightarrow v_f = \sqrt{\frac{2 \times 1.31}{m}} \text{ m/s}$$

$$= \sqrt{\frac{2 \times 1.31}{3}} \text{ m/s}$$

$$= \boxed{0.935 \text{ m/s}}$$ Ans

$\boxed{Ch-8}$

$\boxed{6}$

mass, $m = 0.032$ kg

$h = 5R$, $R = 12$ cm $= 12 \times 10^{-2}$ m

$= 5 \times 12 \times 10^{-2}$ m

(a) $W_g = mg(4R) = 0.032 \times 9.8 \times 4 \times 12 \times 10^{-2}$ J $= \boxed{0.15 \text{ J}}$

(b) $W_g = mg(3R)$

$= 0.032 \times 9.8 \times 3 \times (12 \times 10^{-2})$ J

(c) $U = mg(5R)$

(d) $U = mg(R)$

(e) $U = mg(2R)$

(f) same

$\boxed{22}$ $m = 60$ kg, $H = 20$ m, $\theta = 28^\circ$

(a) $K_i + U_i = K_f + U_f$

$\Rightarrow 0 + mgH = \frac{1}{2}mv^2 + 0$

$\Rightarrow v = \sqrt{2gH}$

$= \sqrt{2 \times 9.8 \times 20}$ m/s

$= 19.8$ m/s

$h = \frac{v^2}{2g} \sin^2\theta$

$= \frac{(19.8)^2}{2 \times 9.8} \times \sin^2(28^\circ)$

$= \boxed{4.4 \text{ m}}$

(b) Same.

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$$U_i + K_i = U_f + K_f$$

$$\Rightarrow mg(h+x) + 0 = \frac{1}{2}kx^2 + 0$$

$$\Rightarrow mgh + mgx - \frac{1}{2}kx^2 = 0$$

$$\Rightarrow 2mgh + 2mgx - kx^2 = 0$$

$$\Rightarrow kx^2 - 2mgx - 2mgh = 0$$

$$\Rightarrow x = \frac{2mg \pm \sqrt{(2mg)^2 - 4k\,2mgh}}{2 \cdot k}$$

$$= \frac{2 \times 2 \times 9.8 \pm \sqrt{(2 \times 2 \times 9.8)^2 - 4 \times 1960 \times 2 \times 9.8 \times 4 \times 10^{-2}}}{2 \times 1960}$$

$$\therefore x = \boxed{0.1 \text{ m}}$$

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$$k = 640 \text{ N/m}$$

$$\mu_k = 0.25$$

$$m = 3.5 \text{ kg}, \quad D = 7.8 \text{ m}$$

(a) $$\Delta E_{th} = f_k D = \mu_k F_N D$$

$$= \mu_k mgD$$

$$= 0.25 \times 3.5 \times 9.8 \times 7.8 \text{ J}$$

$$= \boxed{67 \text{ J}}$$

(b) $$K_{max} = \Delta E_{th} = \boxed{67 \text{ J}}$$

(c) $$\frac{1}{2}kx^2 = K_{max} \Rightarrow x = \sqrt{\frac{2K_{max}}{k}} = \sqrt{\frac{2 \times 67}{640}} \text{ m} = \boxed{0.46 \text{ m}}$$

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$$\frac{1}{2}mv_0^2 = mgh + \Delta E_{th}$$

$$\Rightarrow \frac{1}{2}mv_0^2 = mgh + \mu_k mgd$$

$$\Delta E_{th} = f_k d$$
$$= \mu_k F_N d$$
$$= \mu_k mgd$$

$$\Rightarrow \mu_k mgd = \frac{mv_0^2}{2} - mgh$$

$$\Rightarrow d = \frac{mv_0^2}{2\mu_k mg} - \frac{mgh}{\mu_k mg}$$

$$= \frac{v_0^2}{2\mu_k g} - \frac{h}{\mu_k}$$

$$= \left(\frac{(6)^2}{2\times 0.6\times 9.8} - \frac{1.1}{0.6}\right) m$$

$$\boxed{\therefore d = \boxed{1.2 m}}$$ Ans

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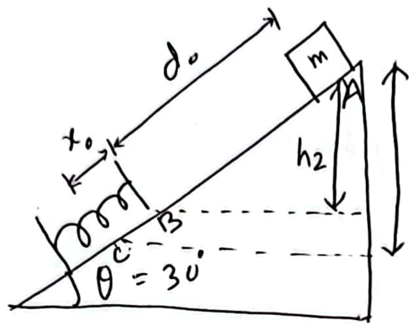


$m = 12\ kg$

$K = \frac{F}{x} = \frac{270N}{0.02m} = 1.35\times10^4 N/m$

$x_o = 5.5\times10^{-2} m$

$d_o = ?$

(a) According to conservation of Energy,

$$U_A + K_A = U_c + K_B$$

$$mgh_1 + 0 = \frac{1}{2}kx_o^2 + 0$$

$$\Rightarrow mg(x_o + d_o)\sin\theta = \frac{1}{2}kx_o^2$$

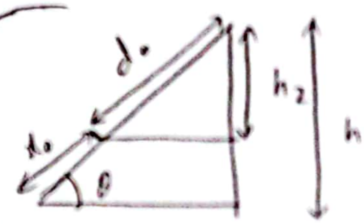
$$\Rightarrow mgx_o\sin\theta + mgd_o\sin\theta = \frac{1}{2}kx_o^2$$

$$\Rightarrow mgd_o\sin\theta = \frac{1}{2}kx_o^2 - mgx_o\sin\theta$$

$$\Rightarrow d_o = \frac{\frac{1}{2}kx_o^2 - mgx_o\sin\theta}{mg\sin\theta}$$

$$= \frac{\frac{1}{2}\times 1.35\times10^4\times(5.5\times10^{-2})^2 - 12\times9.8\times5.5\times10^{-2}\sin30°}{12\times9.8\times\sin30°} m$$

$$= \boxed{0.292\ m}$$



$\sin\theta = \frac{h_1}{x_o + d_o}$

$\Rightarrow h_1 = (\sin\theta)(x_o + d_o)$

(b)

$$U_A + K_A = U_B + K_B$$

$$\Rightarrow mgh_2 + 0 = 0 + \frac{1}{2}mv^2$$

$$\Rightarrow g\,d_o \sin\theta = \frac{1}{2}v^2$$

$$\sin\theta = \frac{h_2}{d_o}$$

$$\Rightarrow v = \sqrt{2 g d_o \sin\theta}$$

$$\Rightarrow d_o \sin 30^\circ = h_2$$

$$= \sqrt{2 \times 9.8 \times 0.292 \times \sin 30^\circ} \text{ m/s}$$

$$\simeq 1.7 \text{ m/s}$$

30

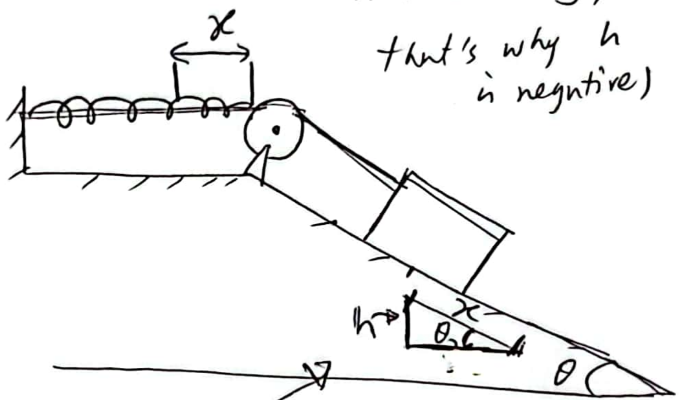
(a) Here the system is conservative, so,

$$K_i + U_i = K_f + U_f \Rightarrow 0 + 0 = K_f + U_f$$

$$\Rightarrow K_f + U_f = 0$$

$$\Rightarrow \frac{1}{2}mv^2 + \frac{1}{2}kx^2 + mg(-h) = 0 \quad \text{——(1)}$$

(gravitational potential energy is decreasing, that's why h is negative)



here, $x = 10\,cm = 10\times10^{-2}\,m$

$m = 2\,kg$

$\theta = 40°$

$k = 120\,N/m$

$$\sin\theta = \frac{h}{x}$$

$$\Rightarrow h = x\sin\theta$$

$$= 10^{-1}\times\sin(40°)\,m$$

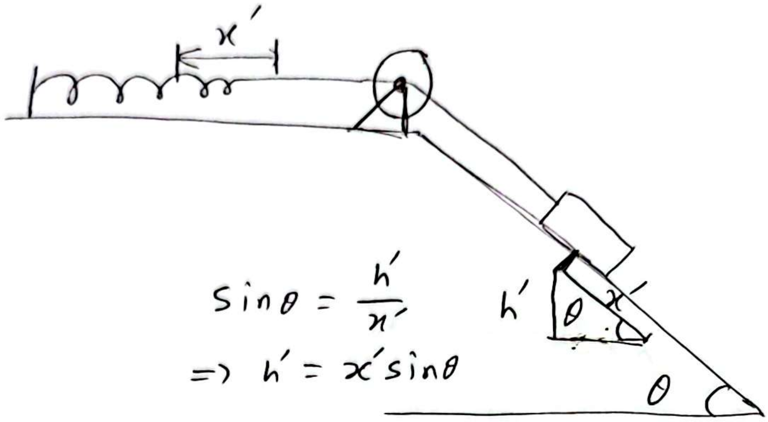
From eqn (1),

$$\frac{1}{2}mv^2 = mgh - \frac{1}{2}kx^2$$

$$\Rightarrow v = \sqrt{\frac{2\left(mgh - \frac{1}{2}kx^2\right)}{m}} = \sqrt{\frac{2\times\left[2\times9.8\times10^{-1}\sin(40°) - \frac{1}{2}\times120\times(10^{-1})^2\right]}{2}}\ m/s$$

$$= \boxed{0.81\ m/s}$$

(b) $\frac{1}{2}mv'^2 + \frac{1}{2}kx'^2 + mg(-h') = 0$ — (2)



$\sin\theta = \frac{h'}{x'}$

$\Rightarrow h' = x'\sin\theta$

here

$v' = 0$,

From eqn (2),

$$\frac{1}{2}kx'^2 - mgx'\sin\theta = 0$$

$$\Rightarrow x'\left(\frac{1}{2}kx' - mg\sin\theta\right) = 0$$

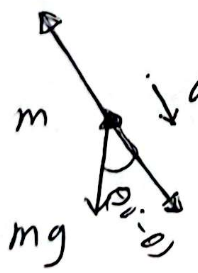
$$\therefore x' = \frac{2mg\sin\theta}{k}$$

$$= \frac{2\times 2\times 9.8\sin(40^\circ)}{120} \text{ m}$$

$$= 0.21 \text{ m}$$

(c)

$T = kx' = (120 \times .21)\text{ N} = 25.2\text{ N}$



$mg\cos(90^\circ-\theta) = mg\sin\theta$

$(\sin\theta)mg - T = ma$

$$\Rightarrow a = \frac{mg\sin\theta - T}{m}$$

$$= \frac{2\times 9.8\times \sin(40^\circ) - 25.2}{2} \,(\text{m/s}^2)$$

$$= \frac{-12.6}{2}\text{ m/s}^2 = -6.3\text{ m/s}^2$$

(d) Direction of the acceleration is upward.

$\boxed{\text{Solve} \rightarrow 31}$ solve it yourself.

$\boxed{36}$

$$\frac{1}{2} k x_{compress}^2 = \frac{1}{2} m v_0^2$$

$$\Rightarrow v_0 = \sqrt{\frac{k}{m}}\, x_{compress}$$

$$v_0 \propto x_{compress}$$

$$\frac{V_{01}}{V_{02}} = \frac{x_{compress,1}}{x_{compress,2}} \quad \text{——(1)}$$

$$x = v_0 \cos 0^\circ t \quad \text{and} \quad h = \frac{1}{2} g t^2$$

$$\Rightarrow t = \sqrt{\frac{2h}{g}}$$ so t doesn't depend on V_0.

$$\therefore x \propto V_0$$

$$\frac{x_1}{x_2} = \frac{V_{01}}{V_{02}} \quad \text{——(2)}$$

From (1) and (2), $\dfrac{x_{compress,1}}{x_{compress,2}} = \dfrac{x_1}{x_2}$

$x_1 = (2.20 - 0.27)\text{ m} = 1.93\text{ m}$

$x_2 = 2.20\text{ m}$

$x_{compress,1} = 1.1\text{ cm}$

$x_{compress,2} = ?$

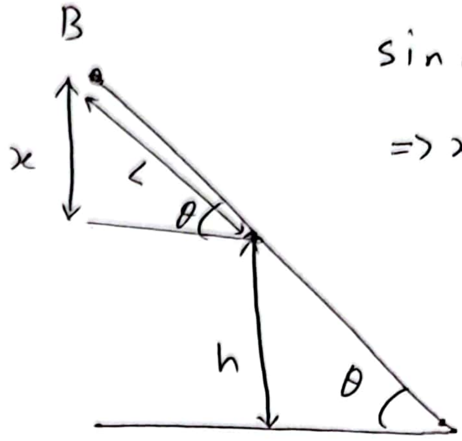
$$\Rightarrow x_{compress,2} = \frac{x_2}{x_1} x_{compress,1}$$

$$= \frac{2.20}{1.93} \times 1.1\text{ cm}$$

$$= \boxed{1.25\text{ cm}}$$

(Ans)

$\boxed{62}$



$\sin\theta = \frac{x}{L}$

$\Rightarrow x = L\sin\theta$

$= 0.75\sin(30^\circ)$

$= \frac{0.75}{2}$

$$\frac{1}{2}mv^2 = mg(h+x) + \Delta E_{th} + \frac{1}{2}mv'^2$$

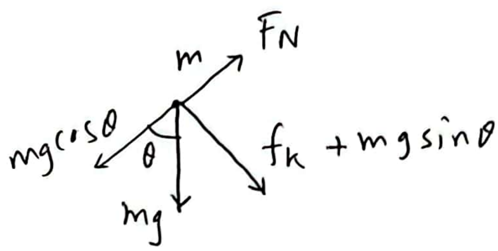
$$\Rightarrow \frac{1}{2}mv'^2 = \frac{1}{2}mv^2 - mg(h+x) - \Delta E_{th}$$

$$\left[\begin{aligned}\Delta E_{th} &= \mu_k F_N L \quad (= f_k L) \\ &= \mu_k\, mg\cos\theta\, L\end{aligned}\right]$$

$$\Rightarrow \frac{1}{2}\cancel{m}v'^2 = \frac{1}{2}\cancel{m}v^2 - \cancel{m}g(h+x) - \mu_k \cancel{m}g\cos\theta L \quad \text{——} (1)$$

$$\cancel{\Rightarrow \frac{1}{2}v'^2 = \frac{1}{2}\times 8^2 - g\left(2+\frac{0.75}{2}\right) - 0.4\cos 30^\circ \times (0.75)}$$

$$\cancel{\Rightarrow \frac{1}{2}v'^2 = \frac{64}{2} - 9.8\times\left(2+\frac{0.75}{2}\right) - 0.4\cos(30^\circ)\times 0.75}$$



$$\Rightarrow \frac{v'^2}{2} = \frac{8^2}{2} - 9.8\times\left(2+\frac{0.75}{2}\right) - 0.4\times 9.8\cos(30^\circ)\times 0.75$$

$= 6.18$ so, $v'^2 > 0$, so the block can be reached at point B.

The the velocity at the point B, $v' = \sqrt{2\times 6.18}$ m/s

$= \boxed{3.52 \text{ m/s}}$