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WORK - ENERGY THEOREM

Statement :- Work done by all the forces either conservative, or non-conservative or others is equal to change in kinetic energy of the body.

$$\boxed{W_{conservative} + W_{non\text{-}conservative} + W_{others} = \Delta K.E}$$

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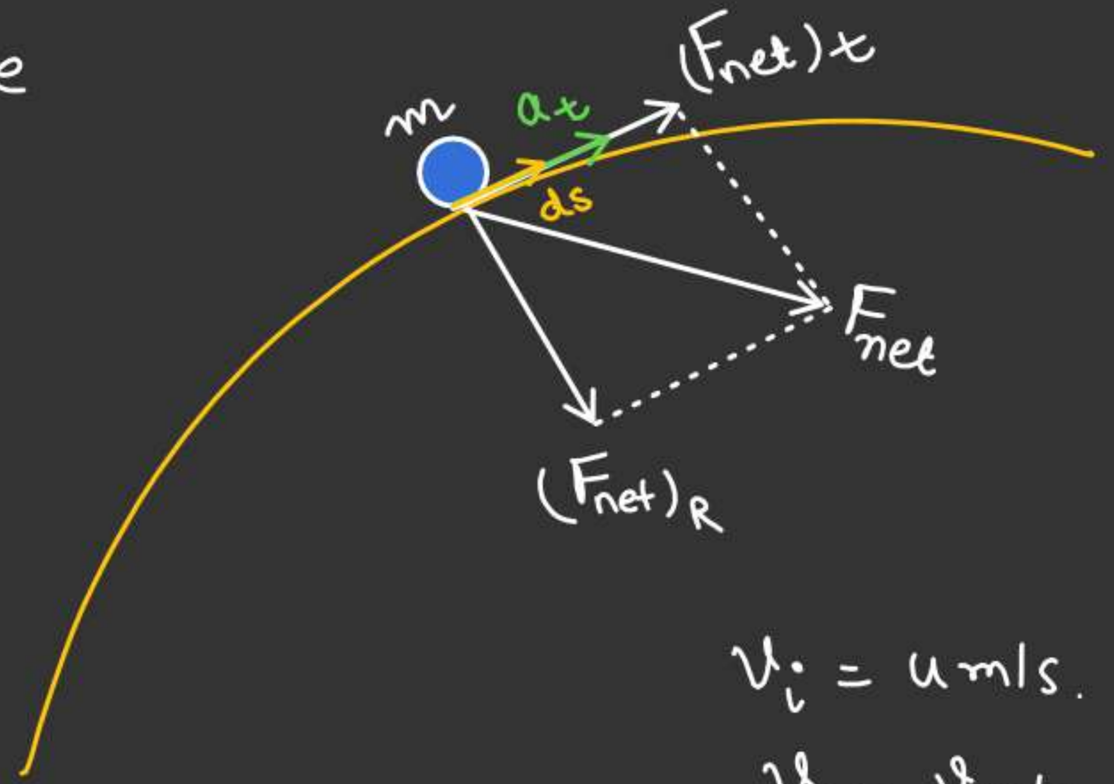
$$\vec{F}_{net} = \vec{F}_{conservative} + \vec{F}_{non\text{-}conservative} + \vec{F}_{others}.$$

$(F_{net})_t$ = Net tangential force

$(F_{net})_R$ = Net Radial force.



W_{net} only due to $(F_{net})_t$.

let, dW be the work done for ds displacement

$v_i = u$ m/s.

$v_f = v$ m/s.

$$dW = (F_{net})_t \cdot ds \qquad a_t = v\left(\frac{dv}{ds}\right)$$

$$dW = \underline{m\, a_t} \cdot ds.$$

$$dW = m\, v \frac{dv}{\cancel{ds}} \times \cancel{ds} \Rightarrow \int_0^{W_{net}} dW = m \int_u^v v\, dv \Rightarrow W_{net} = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\boxed{W_{net} = \Delta K \cdot E}$$

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ENERGY CONSERVATION

* Energy Conservation is the Special Case of work-Energy theorem. when only Conservative forces present.

i.e $W_{non-Conservative} = 0, \quad W_{others} = 0$

By work-Energy theorem

$$W_{conservative} + \cancel{W_{non-Conservative}}^{0} + \cancel{W_{others}}^{0} = \Delta K.E$$

$$W_{conservative} = \Delta K.E$$

By def^n of P.E

$(W_{conservative} = -\Delta U)$

$$\Downarrow$$

$$-\Delta U = \Delta K.E$$

$$-(U_f - U_i) = K.E_f - K.E_i$$

$$\boxed{U_i + K.E_i = U_f + K.E_f} \rightarrow$$

Total Mechanical energy remains Constant

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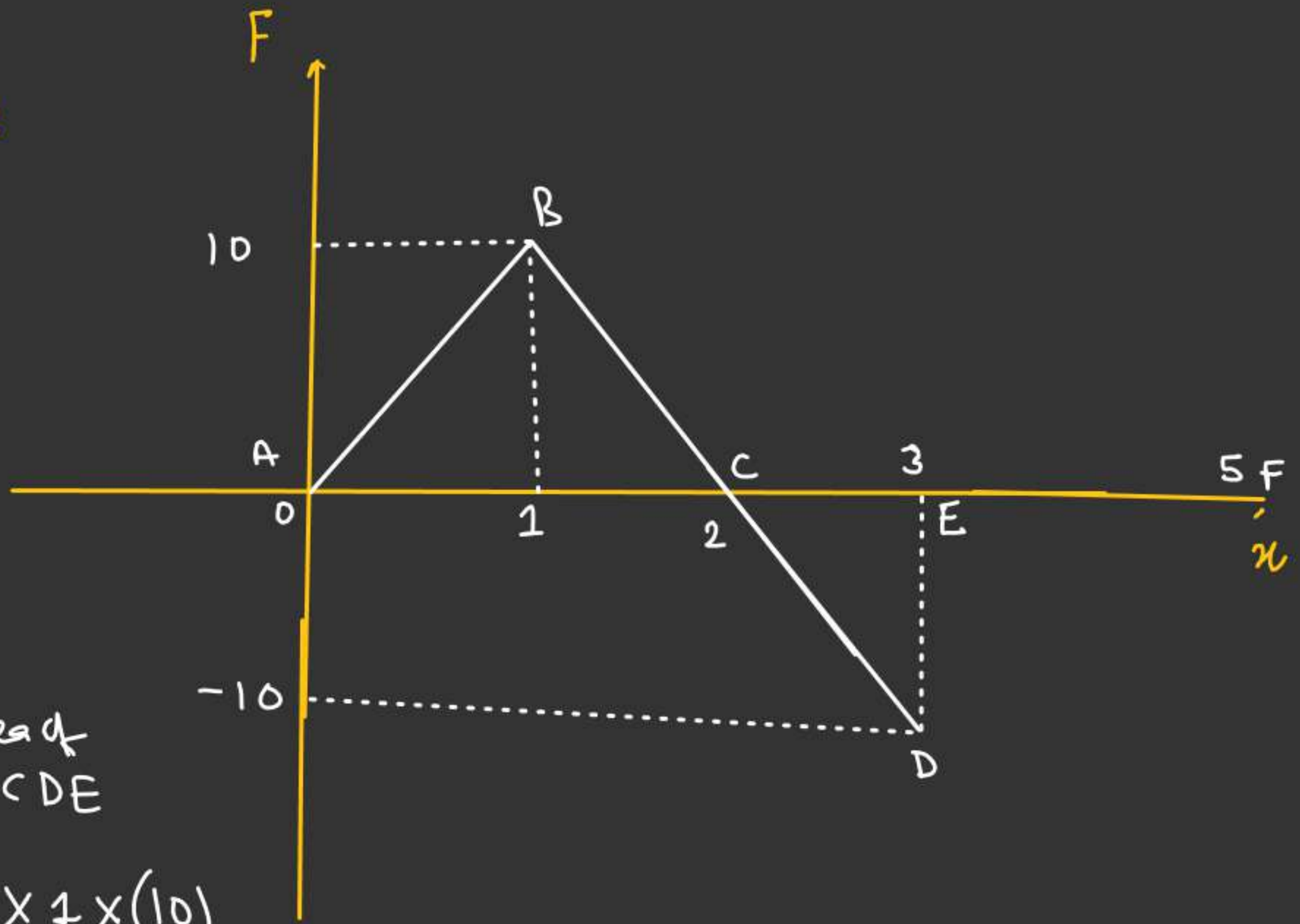
Force acting on a particle which is initially at rest. graph shows the variation of F as a function of x.

Mass of particle is 2 Kg.

Find velocity of particle at

a) $x = 3m$



Sol^n :- a) By work energy theorem.

$$W_F = \text{Area of } \Delta ABC + \text{Area of } \Delta CDE$$

$$= \left(\tfrac{1}{2} \times 2 \times 10\right) - \tfrac{1}{2} \times 1 \times (10)$$

$$= 10 - 5 = 5.$$

$$W_F = 5$$

$$\tfrac{1}{2} m(v_f^2 - \underset{\Downarrow \atop 0}{v_i^2}) = 5 \Rightarrow v_f = \sqrt{5}\, m/s.$$

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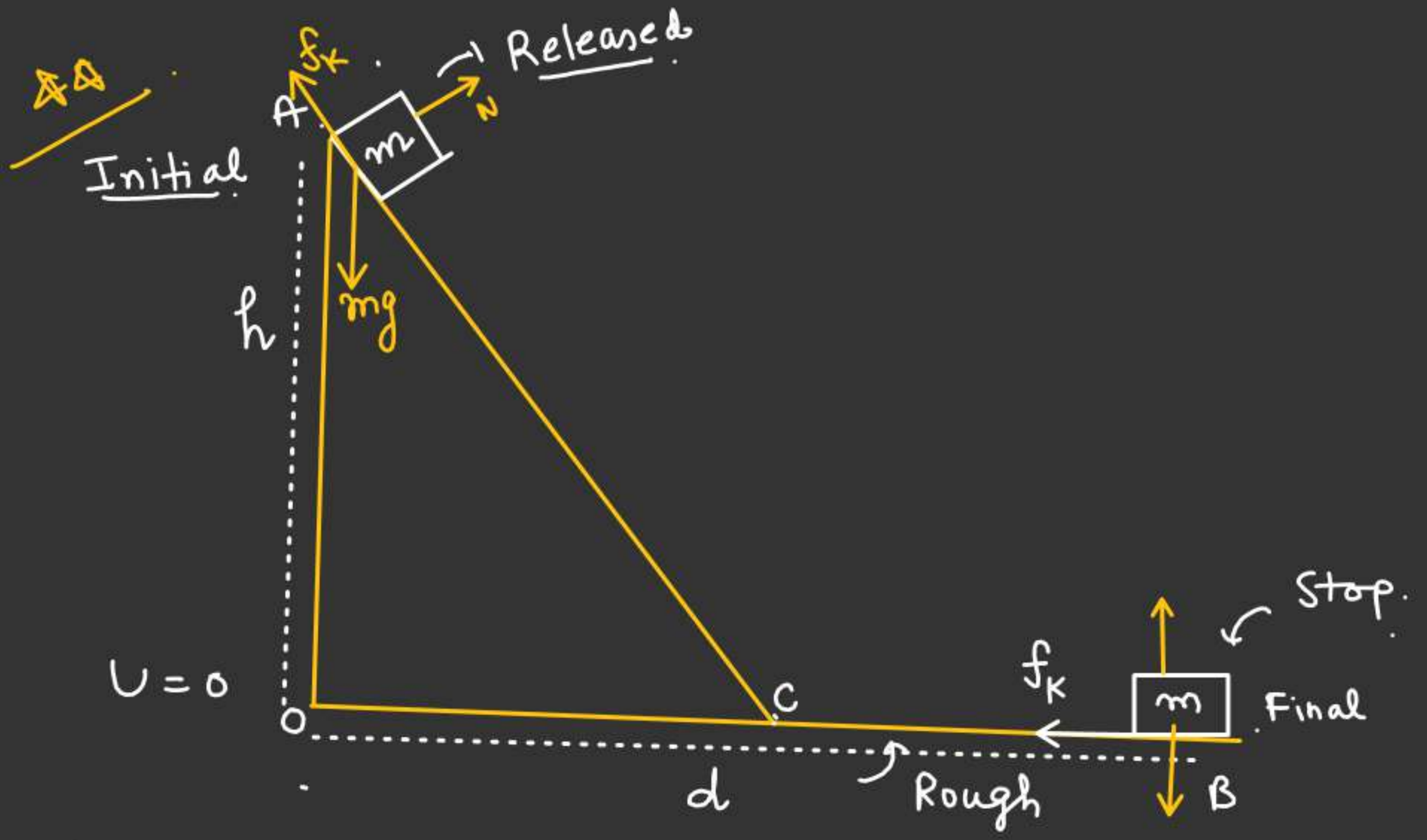

Find $\mu = ??$ if block stops after travelling a distance d.

μ = Cofficient b/w block and both the Surfaces.

All the Surfaces is rough.

Sol^n :- Work-Energy theorem for path A to B.

$$W_{mg} + W_{f_K} + W_N = \Delta K.E \quad -(1)$$

$$W_{mg} = -\Delta U$$
$$= -(U_f - U_i)$$
$$= -(0 - mgh)$$
$$= +mgh$$

Put in (1)

$W_N = 0$

$W_{mg} = (W_{mg})_{A-C} + \cancel{(W_{mg})_{C-B}}^{\,0}$

$= (mgh)$

$W_{f_K} = -\mu mgd$

$\Delta KE = 0$

$mgh - \mu mgd = 0$

$$\boxed{\mu = \frac{h}{d}}$$

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Find the distance from B where the ball finally stop.

AB and CD are Smooth track.
BC is Rough. ($L_{BC} = 3m$).

By work-Energy theorem

$$W_{mg} + W_{f_k} + \cancel{W_N}^{0} = \Delta K.E$$

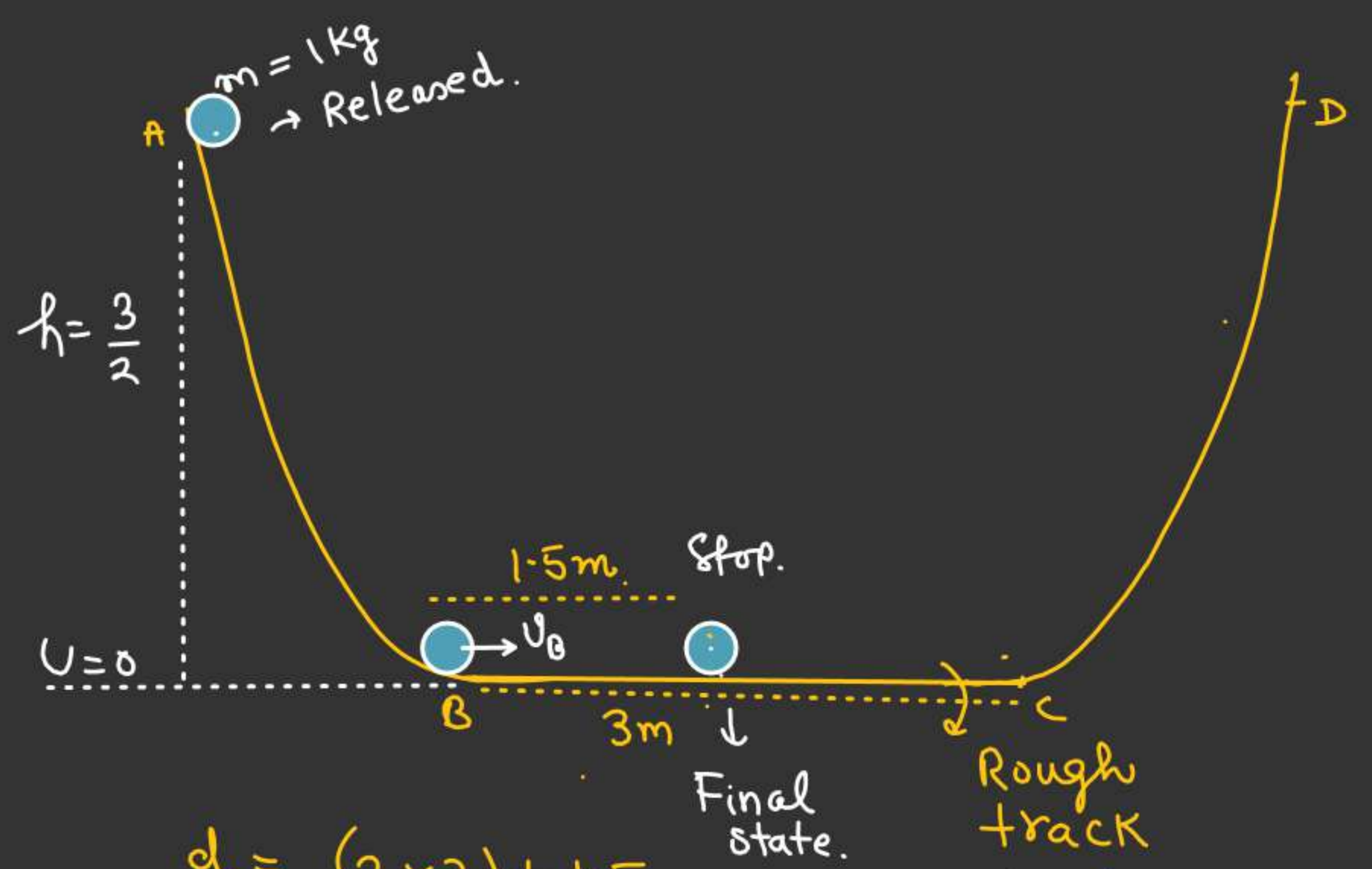
$\downarrow$ $\quad \Delta K.E = 0 \quad K.E_f = 0$

$$mg\frac{3}{2} - \mu mgd = 0 \quad K.E_i = 0.$$

d = Total distance covered.

$$\frac{3}{2}\cancel{mg} = \mu \cancel{mg} d$$

$$d = \frac{3 \times 10}{2 \times 2} = \frac{30}{4} = \underline{7.5m}.$$



$d = (2 \times 3) + \underline{1.5}$

Ball stop at a distance 1.5m from B.

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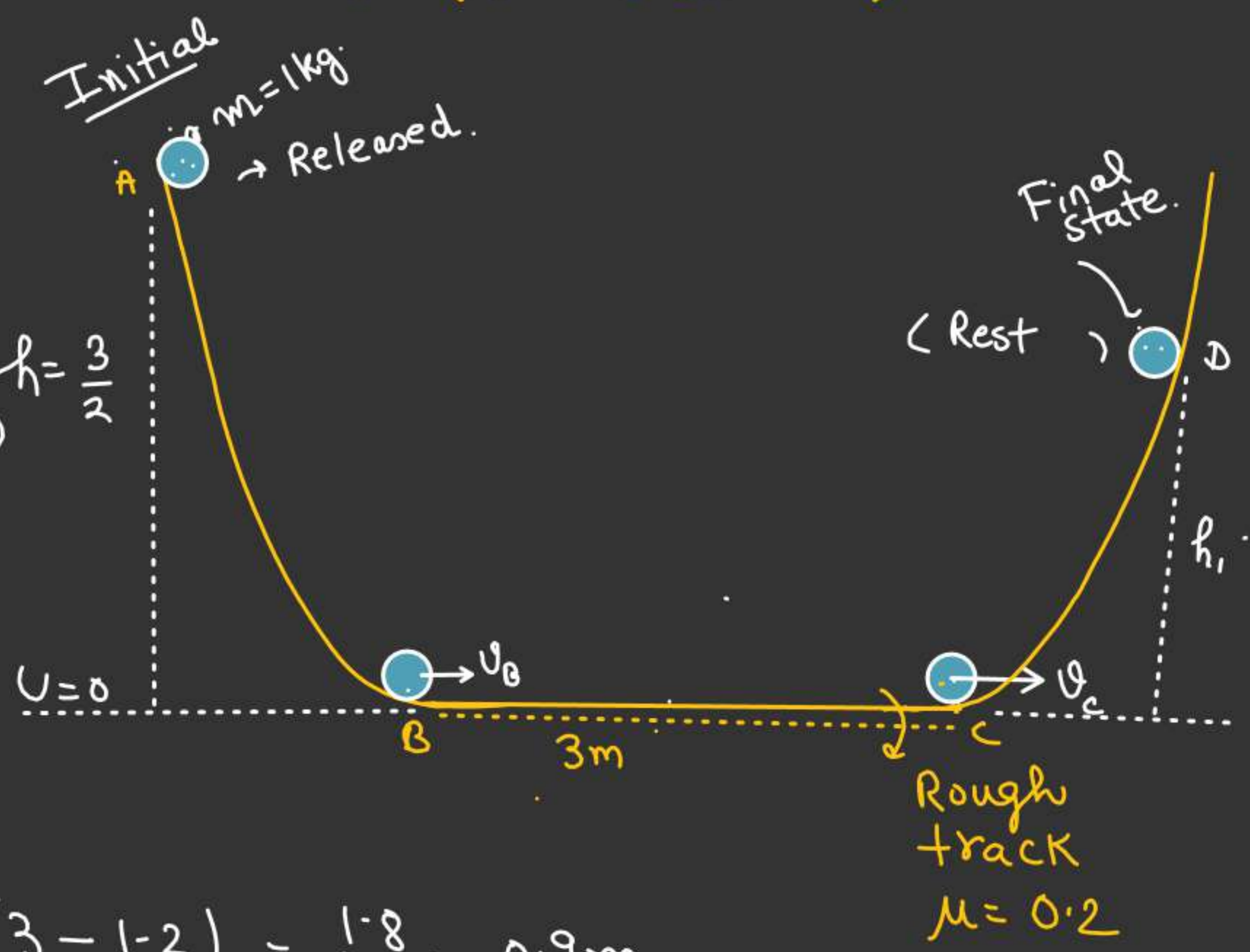
(b) Find maximum height attained by the ball from C 1st time.

AB and CD are Smooth track.
BC is Rough. $(L_{BC} = 3m)$.



For A to D

$$W_{mg} + W_{f_K} + W_N = \Delta K.E$$

$$W_N = 0$$

$$\left[(W_{mg})_{A\to B} + (W_{mg})_{C\to D}\right] + (W_{f_K})_{BC} = 0$$

$$h = \frac{3}{2}$$

$$\frac{3}{2}mg - mgh_1 - \mu mg\times 3 = 0$$

$$\frac{3}{2}mg - (0.2\times 3)mg = mgh_1$$

$$h_1 = \left(\frac{3}{2} - 0.6\right) \Rightarrow h_1 = \left(\frac{3-1.2}{2}\right) = \frac{1.8}{2} = \underline{0.9m}$$