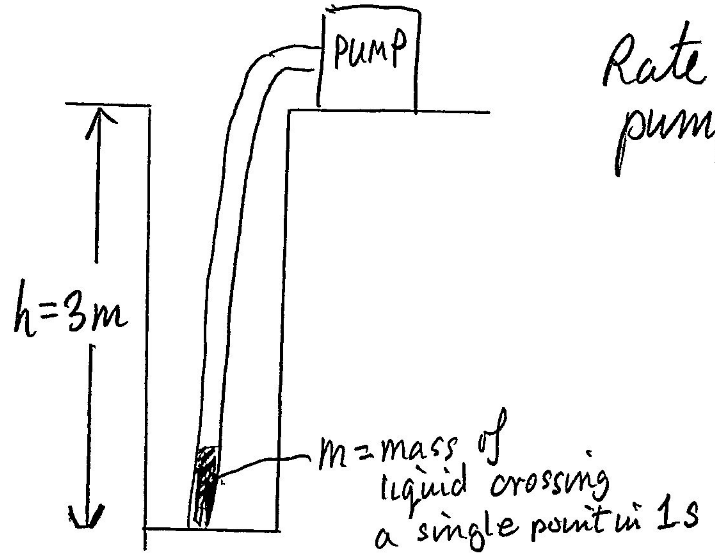
PHY1010

Tutorial 5

Work & Power:

1 hp = 746 W

Q1



Rate of pumping $= 0.6 \frac{Kg}{min}$

$= 0.6 \frac{Kg}{(60s)}$

$= 0.01\ Kg.s^{-1}$

$h = 3m$

→ Since the rate of pumping is $0.01\ Kg.s^{-1}$, ∴ the energy needed each second to raise 0.01Kg by 3m is

$$E_{1s} = mgh = (0.01)(9.81)(3)$$
$$= 0.2943\ J.s^{-1}$$

→ But, energy per second is power, hence

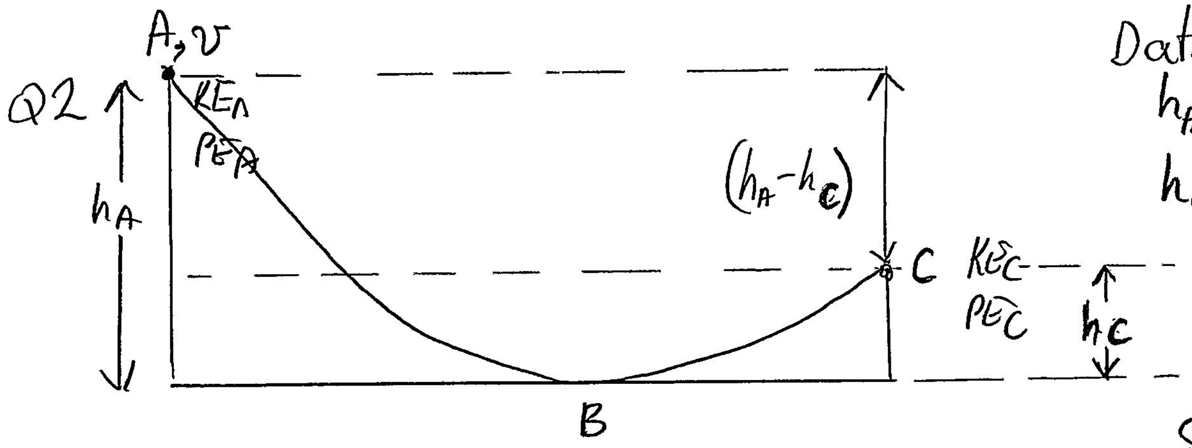
$$P = \frac{E}{t} = \frac{0.2943\ J}{1\ s} = 0.2943\ W$$

→ Now 1 hp = 746 W so that

$$P = 0.2943\,W = 0.2943\left(\frac{1}{746}hp\right) = 3.945 \times 10^{-4}\,hp$$

Ans. Minimum power of pump = 0.294 W = 3.95×10^{-4} hp

Q2



Data:

$h_A = 80cm = 0.8m$

$h_C = 50cm = 0.5m$

$v = 2ms^{-1}$

$m = 15g = 0.015 \, Kg$

$S = 250cm = 2.5m$

$g = 9.81ms^{-1}$

By conservation of energy:

ENERGY LOST = ENERGY GAINED + WORK DONE BY FRICTION

$KE_A = \frac{1}{2}mv^2$, $KE_C = 0$

$PE_A = mgh_A$, $PE_C = mgh_B$

The ΔKE lost is

$$\Delta KE = KE_A - KE_C = \left(\frac{1}{2}mv^2 - 0\right)$$
$$= \frac{1}{2}(0.015)2^2 = 0.03J$$

The ΔPE lost is

$$\Delta PE = PE_A - PE_C = mg(h_A - h_B)$$
$$= (0.015)(9.81)(0.8 - 0.5)$$
$$= 0.04415 \, J$$

work done by friction $= f.S$

→ Sub. we get

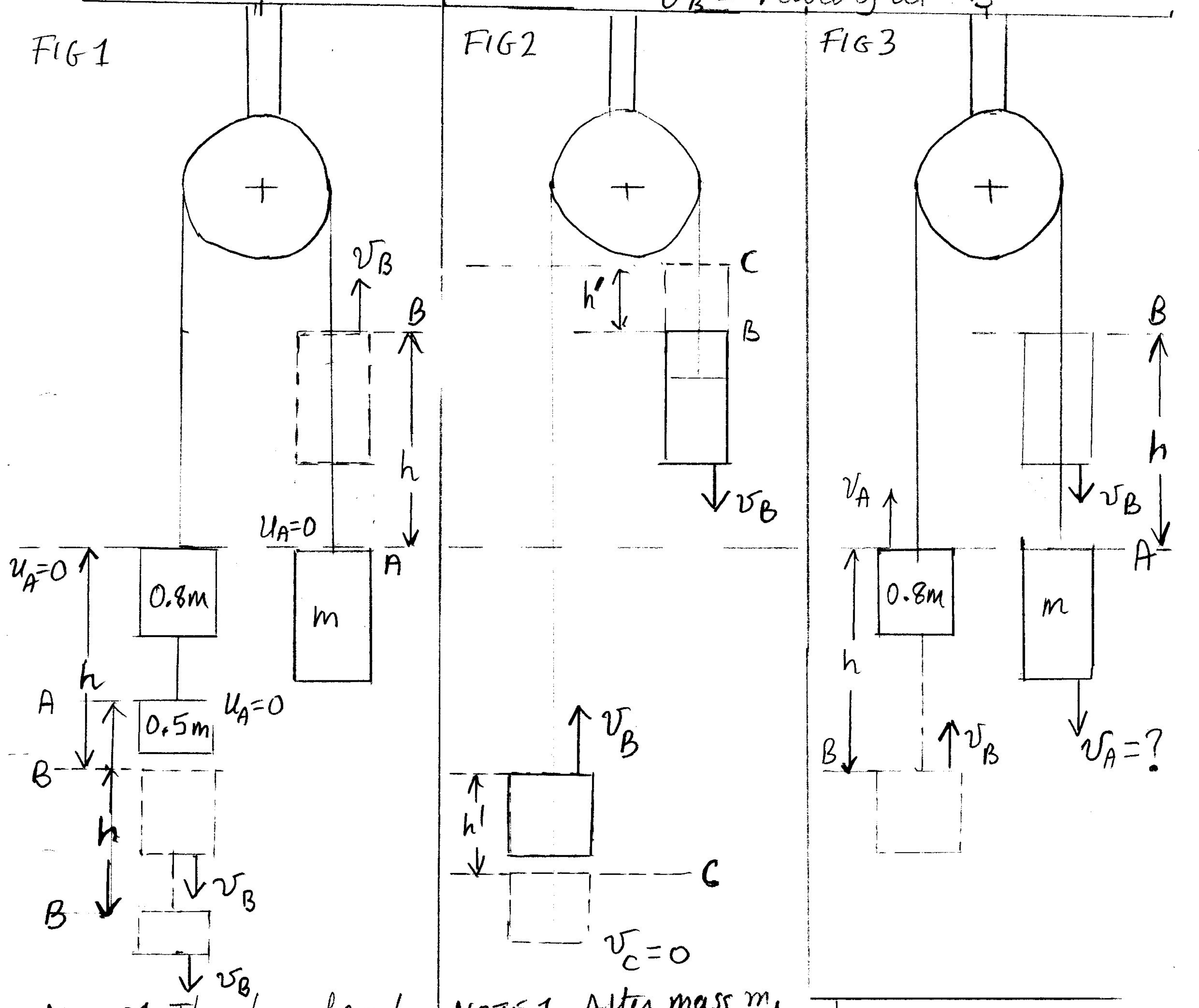
$$(\Delta KE + \Delta PE)_{LOST} = (0)_{GAINED} + f.S$$

$$f = \frac{(\Delta KE + \Delta PE)_{LOST}}{S} = \frac{0.03 + 0.04415}{2.5} = 0.02966N$$

Ans. Frictional force $f = 0.0297 \, N$ (3sf)

Q6. DATA: $g = 9.81\,ms^{-2}$
Friction is zero
$h = 75\,cm = 0.75\,m$

v_C = velocity at C = 0
u_A = initial velocity at A = 0
v_A = final velocity at A
v_B = velocity at B



NOTE 1. The top of each mass is chosen as the reference point for the distance moved by each mass.

NOTE 2. Each mass moves from A to B a distance h

NOTE 1. After mass m, is cut mass 0.8m continues moving downward a furth distance h' where it stops and reverses direction. Similarly mass m reaches a furthe height h', stops and reverses direction.

NOT2: MASS 0.8m and m DO NOT STOP AND REVERSE DIRECTION INSTANANEOUSLY. THE WOULD REQUIRE AN INFINITE ACCELERATION (IMPOSSIBLE)

NOTE 3. By conservation of energy, when 0.8m and m return to position B, their velocity is still v_B, but in the opposite direction.

Q6 cont

→ First look at the motion in Fig. 1. and apply conservation of energy:

ENERGY LOST = ENERGY GAINED

$$(0.8m)gh + (0.5m)gh = mgh + \frac{1}{2}m(v_B^2 - u_A^2) + \frac{1}{2}(0.8m)(v_B^2 - u_A^2)$$
$$+ \frac{1}{2}(0.5m)(v_B^2 - u_A^2)$$

Since $u_A = 0$ and dividing by m, we get

$$0.8gh + 0.5gh = gh + \frac{1}{2}v_B^2 + 0.4v_B^2 + 0.25v_B^2$$

collecting terms, we get

$$0.3gh = 1.15v_B^2$$

$$v_B = \sqrt{\frac{0.3gh}{1.15}} = \sqrt{\frac{0.3(9.81)(0.75)}{1.15}}$$

$$= 1.385 \text{ ms}^{-1}$$

Fig 2 shows that after mass 0.5m is cut, masses 0.8 m and 0.5 m continue moving in the same direction. But, because m > 0.8 m, both mass begin to slow down, stop and reverse direction. Because energy is conserved (no friction) the mass have velocity v_B when they return to position B, but pointing in the opposite direction

Q6 cont.

→ Now apply conservation of energy to Fig. 3.

Energy lost = Energy gained

$$mgh = (0.8m)gh + \frac{1}{2}m(v_A^2 - v_B^2) + \frac{1}{2}0.8m(v_A^2 - v_B^2)$$

Divide through by m and rearrange,

$$gh - 0.8gh = \frac{1}{2}v_A^2 - \frac{1}{2}v_B^2 + 0.4v_A^2 - 0.4v_B^2$$

$$0.2gh = 0.9v_A^2 - 0.9v_B^2$$

$$0.9v_A^2 = 0.2gh + 0.9v_B^2$$

$$v_A = \sqrt{\frac{0.2gh + 0.9v_B^2}{0.9}}$$

$$v_A = \sqrt{\frac{0.2(9.81)(0.75) + 0.9(1.385)^2}{0.9}}$$

$$v_A = 1.885\ ms^{-1}$$

Ans. The final velocity of mass $m = v_A = 1.89ms^{-1}$ (3sf)