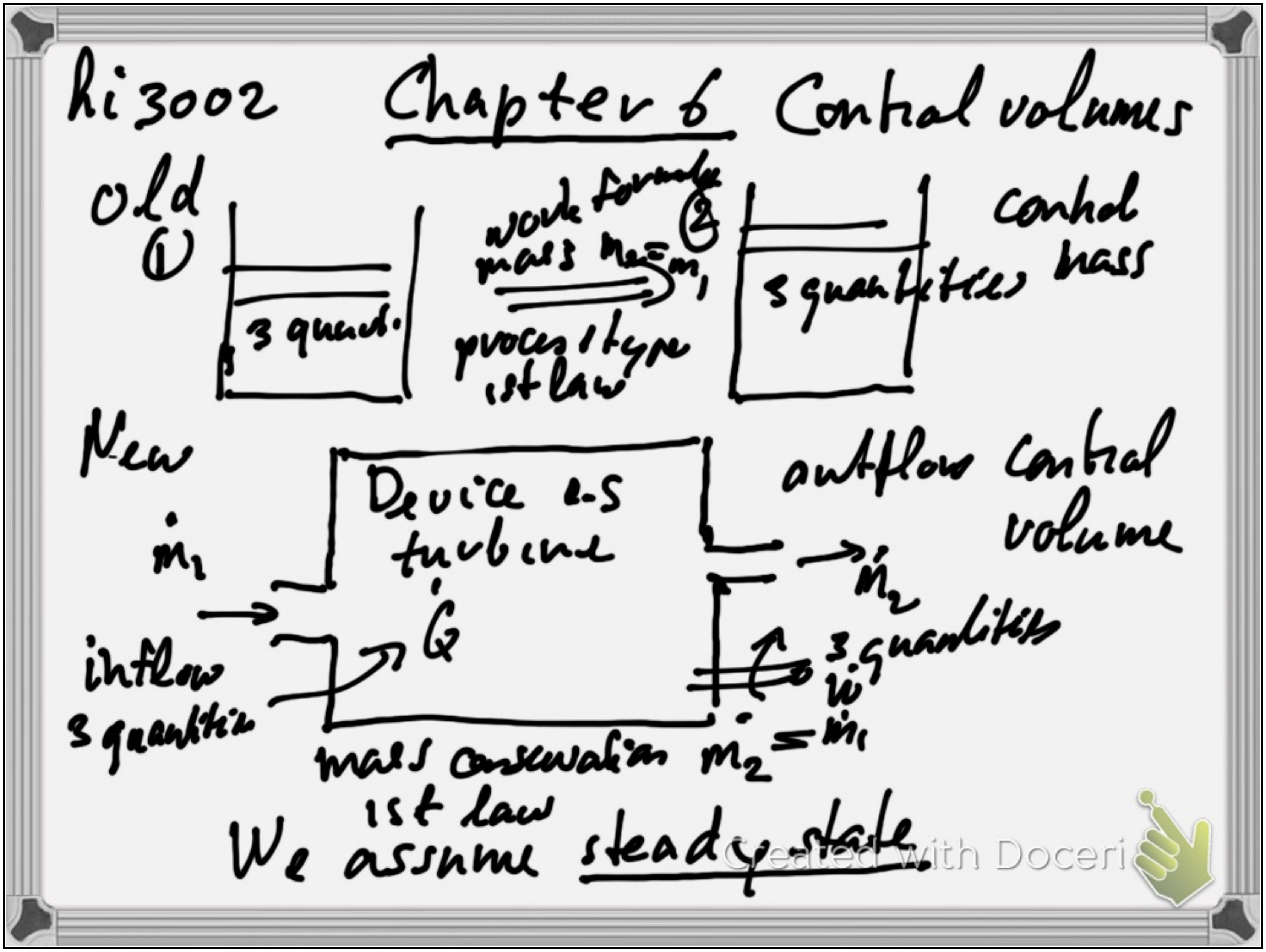
hi 3002
Chapter 6 Control volumes
old
1
3 quant.
work formula
mass m2 = m1
process type
1st law
2
3 quantities
control mass
New
ṁ1
inflow
3 quantities
Device as turbine
Q̇
outflow control volume
ṁ2
3 quantities
Ẇ
mass conservation ṁ2 = ṁ1
1st law
We assume steady state
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Mass conservation

$\dot{m}_{in} = \dot{m}_{exit}$ $\dot{m}$: mass flowrate

$\dot{m}_1 = \dot{m}_2$ if single enhance and single exit (SEE)

If not SEE : sum the enhances and sum the exits together

$\dot{m} = \frac{\dot{V}}{v}$

$\dot{m} = \rho A Vel$

$\dot{m} = \frac{A Vel}{v}$ → specific value

mass flow rate

$\dot{V} = A Vel$

volumetric flow rate

1st law

old C.M. ① $U_2 - U_1 = {}_1Q_2 - {}_1W_2$ ②

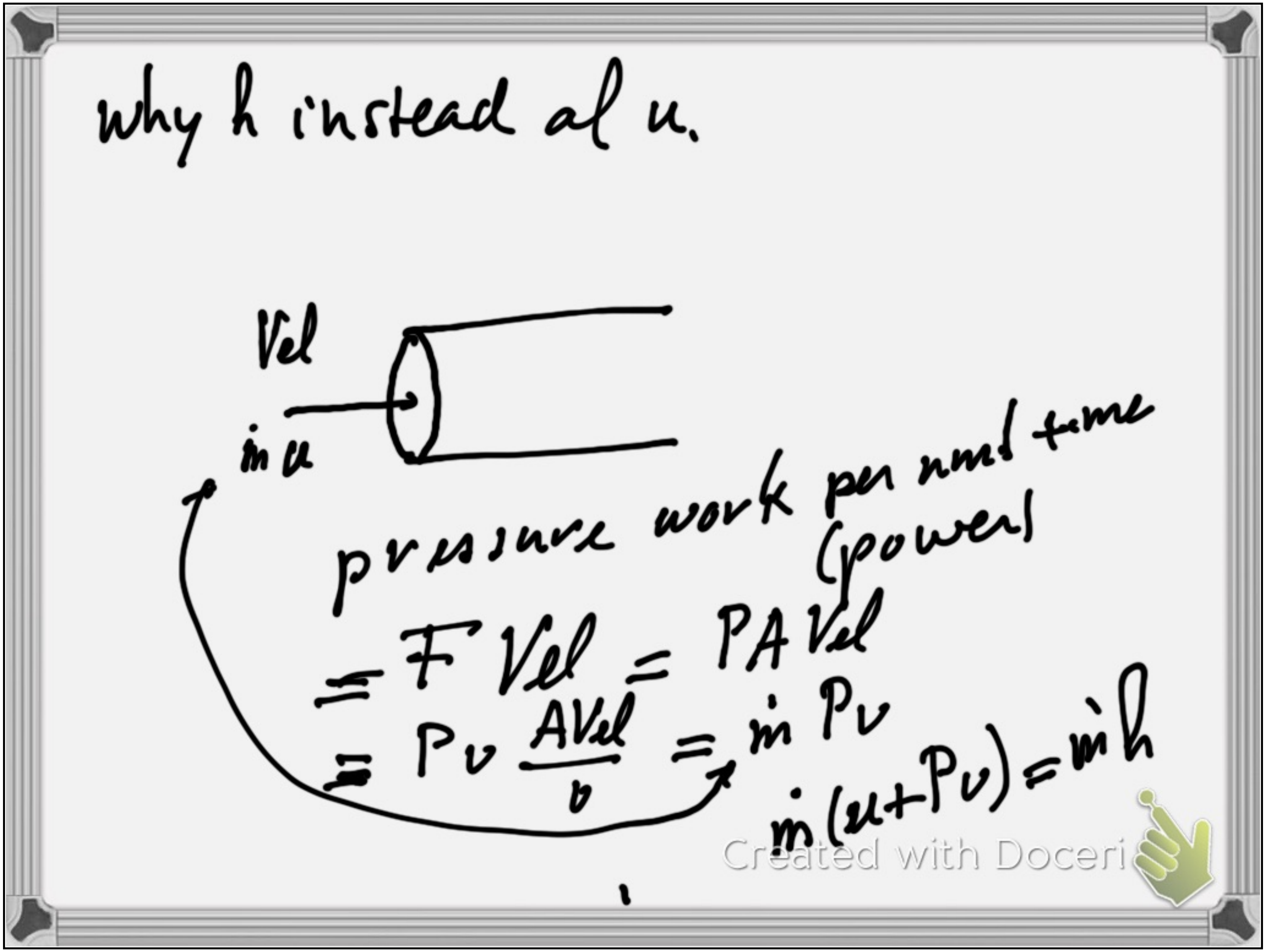
$\rightarrow {}_1Q_2 + U_1 = {}_1W_2 + U_2$

$U_1 \rightarrow m u_1$

new C.V.

$$\dot{Q} + \dot{m}_1\left(h_1 + \frac{1}{2}Vel_1^2 + gZ_1\right) = \dot{W} + \dot{m}_2\left(h_2 + \frac{1}{2}Vel_2^2 + gZ_2\right)$$

If more than one entrance or exit <u>sum them</u>


why h instead of u.
Vel
ṁ u
pressure work per unit time
(power)
= F Vel = P A Vel
= Pv AVel/v = ṁ Pv
ṁ(u+Pv) = ṁh
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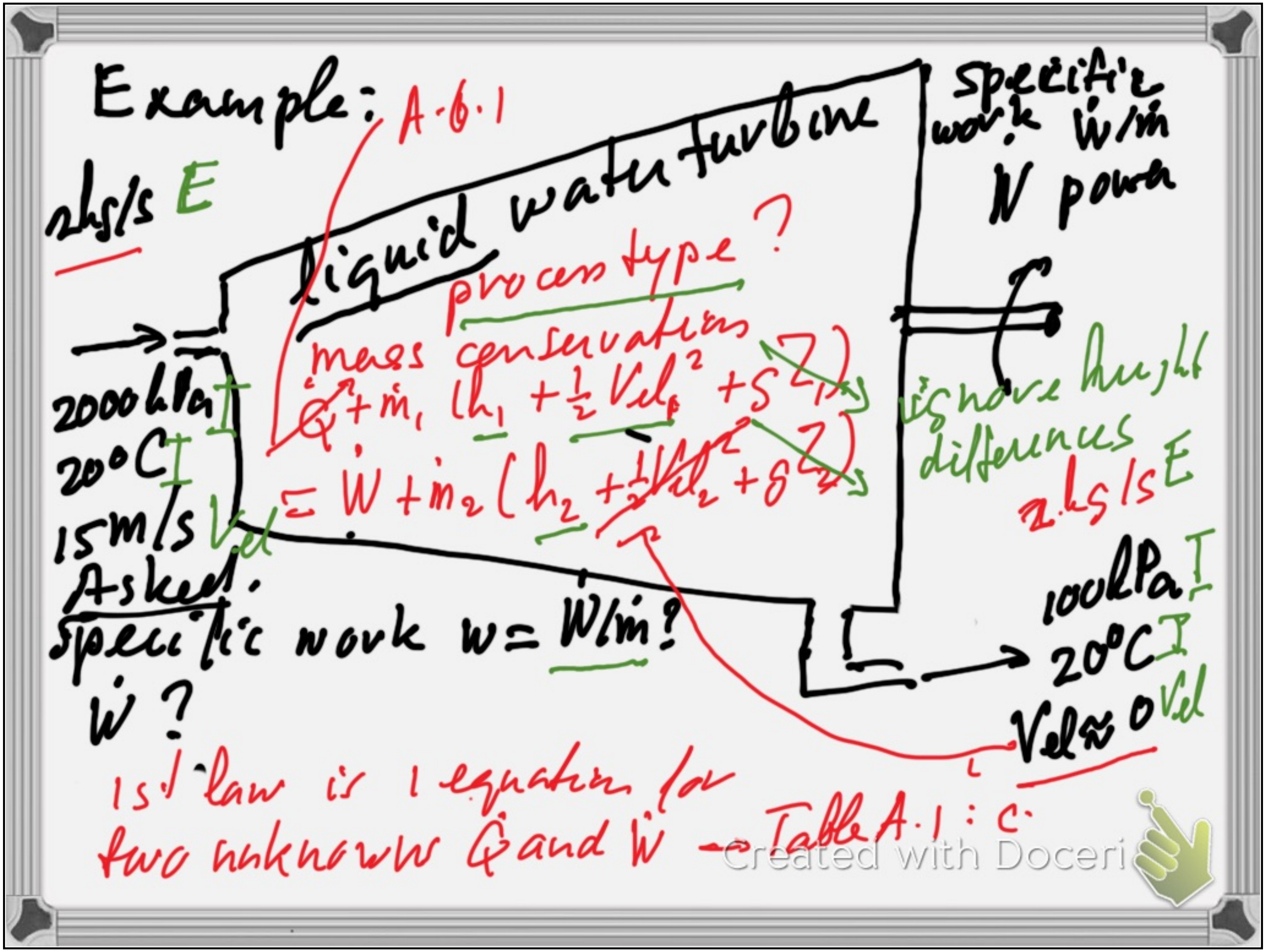
Example: A·6·1
liquid water turbine
specific work W/m
W power
2kg/s E
process type?
mass conservation
Q + m1 (h1 + 1/2 Vel1^2 + g z1)
= W + m2 (h2 + 1/2 Vel2^2 + g z2)
2000 kPa I
20°C I
15 m/s Vel
Asked:
specific work w = W/m?
W ?
ignore height differences
2 kg/s E
100 kPa I
20°C I
Vel≈0 Vel
1st law is 1 equation for
two unknowns Q and W → Table A.1: c
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common assumption for turbines is adiabatic

$\dot{Q} = 0 \quad (q = \dot{Q}/\dot{m} = 0)$

On exams, do not make such assumptions, except (besides gravity): If it does not have moving parts, $W = 0$

e.g. heat exchanger, expansion valve

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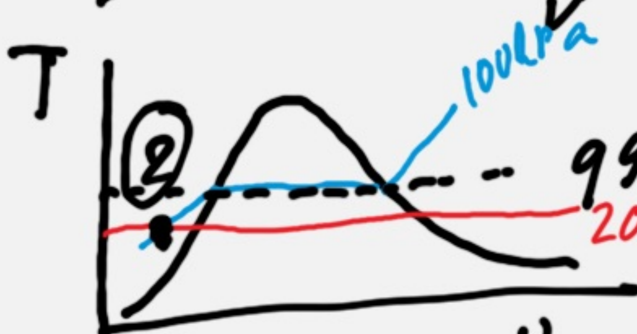
Solution: at ① 2000 kPa, 20°C

212.42°C from B.1.2 @ 2000 kPa

⇓

B.1.4 $h_1 = 85.82 \frac{kJ}{kg}$



99.62°C → B.1.4 ✗

→ B.1.1 @ 20°C

↓

$h_2 = 83.94 \frac{kJ}{kg}$

h_1 : C.L. table B.1.4

$$\dot{Q} + \dot{m}_1 \left(h_1 + \frac{1}{2} Vel_1^2 + \dots\right)$$

$$= \dot{W} + \dot{m}_2 \left(h_2 + \frac{1}{2} Vel_2^2 + \dots\right)$$

$$\frac{kg \frac{m^2}{s^2}}{kg}$$

$$2\left(85.82 + \frac{1}{2} 15^2\right) = \dot{W} + \dot{2}(83.94)$$

$$\dot{W} = 2\left(85.82 - 83.94 + \frac{1}{2} 15^2\right)$$

~~= crap~~

$$2\,\text{kg/s}\left(85.82\,\frac{kJ}{kg} - 83.94\,\frac{kJ}{kg} + \frac{1}{2} 15^2 \frac{m^2}{s^2} \frac{1\,kJ}{1000\,m^2/s^2}\right)$$

$$= 3.8\,\frac{kJ}{sec} = 3.8\,kW \qquad W: Watt$$

$$w = \dot{W}/\dot{m} = 3.8\,\frac{kJ}{s} \Big/ 2\,\frac{kg}{s} = 1.9\,\frac{kJ}{kg}$$