國立臺灣科技大學
113學年度碩士班招生

試題

系所組別：0330機械工程系碩士班丙組

科　　目：熱力與流力

<<503302>>

國立臺灣科技大學 113 學年度碩士班招生試題

系所組別：機械工程系碩士班丙組

科　　目：熱力與流力

（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分）

1. (10%) The following devices are operated between the same high- (900 K) and low-temperature (300 K) reservoirs. Please answer and explain the followings:
   A. (2%) What is the Carnot efficiency for a Carnot heat engine?
   B. (2%) What is the required work input for a Carnot heat pump if the heat ejection is 60 kW?
   C. (2%) Please explain if it is possible to have a refrigerator absorbing 100 kW from the high temperature reservoir (900 K) and ejecting 25 kW to the low temperature reservoir (300 K).
   D. (2%) Judge (true or false) and explain your reason for the following statement. The working fluid is initially kept at saturated vapor state. After an isentropic compression process ($p_2 > p_1$), it becomes superheated vapor.
   E. (2%) Judge (true or false) and explain your reason for the following statement. The working fluid is initially kept at saturated vapor state. After an isothermal compression process ($p_2 > p_1$), it becomes superheated vapor.

2. (8%) Air is compressed in a piston-cylinder device from 100 kPa and 17 °C to 800 kPa in a reversible, adiabatic process. Please determine
   A. (2%) the change of entropy during this process,
   B. (6%) the final temperature and work output for assuming constant specific heat for air.

   Note that R_{air} = 287 J/kg·K , $C_v = 0.727\ \frac{kJ}{kg \cdot K}$, and ρ_{air} = 1.23 kg/m³.

3. (8%) An adiabatic turbine is supplied with 0.6 m³/s of water steadily from a 0.3-m-diameter circular pipe; the outlet pipe has a 0.4 m diameter. Determine the pressure drop across this turbine if it delivers 60 kW. Note that the density of water is ρ=1,000 kg/m³, and the change of internal energy between inlet and outlet of turbine is ignored.

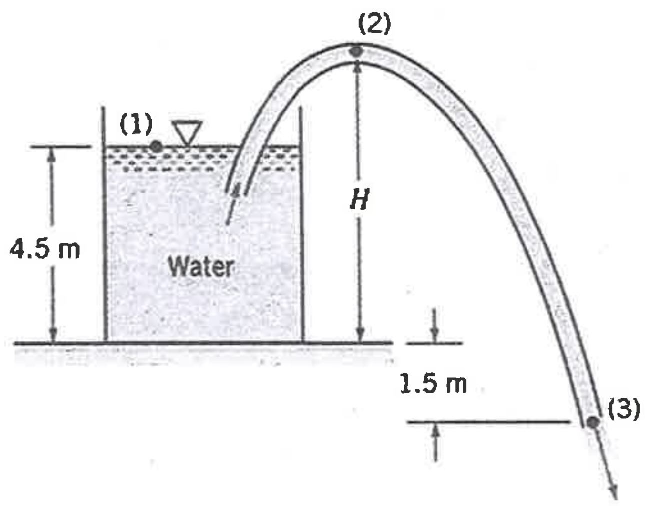
4. (10%) Answer the following questions:
   A. (2%) Write down the definition of the second-law efficiency. How does it differ from the first-law efficiency?
   B. (2%) Write down the detailed processes for Ranking cycle.
   C. (2%) What is the difference between the specific humidity and the relative humidity?
   D. (2%) What is the difference between regeneration and cogeneration?
   E. (2%) What is the combined power cycle? What are its characteristics and purpose?

5. (14%) Nitrogen gas ($R_{nitrogen}$ = 297 J/kg·K) is compressed from 100 kPa and 27 °C to 600 kPa by a 20-kW compressor. Determine the mass flow rate of nitrogen through the compressor, assuming the compression process to be
   A. (4%) the isentropic compression process,
   B. (5%) the polytropic compression process with n=1.2, and
   C. (5%) the ideal two-stage polytropic compression process with n=1.2.

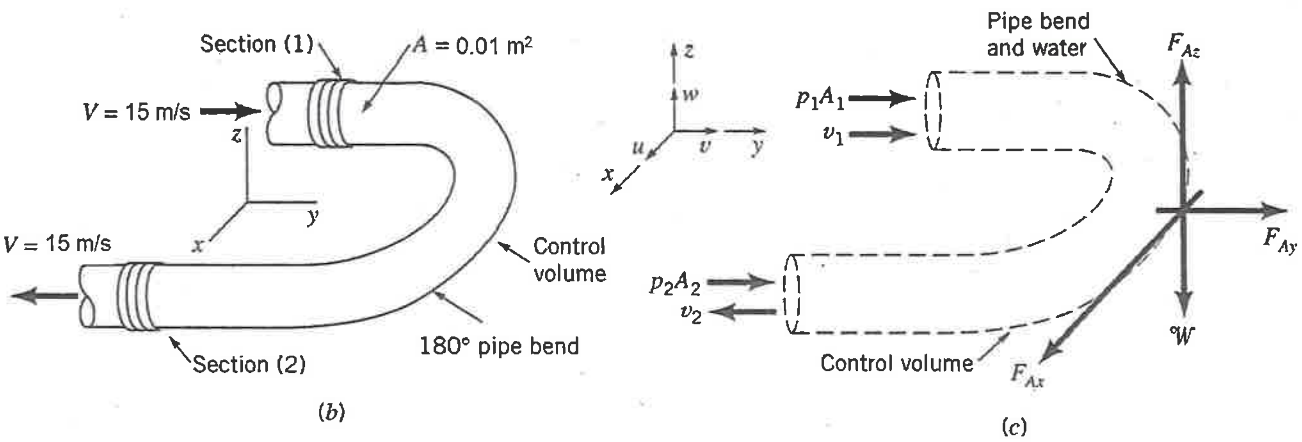
國立臺灣科技大學113學年度碩士班招生試題
系所組別：機械工程系碩士班丙組
科　　目：熱力與流力

（總分為100分；所有試題務必於答案卷內頁依序作答，否則不予計分）

6. (15%) Consider water at 15°C (1000 kg/m^3) being siphoned from a large beaker through a hose with constant diameter. As shown in the below figure, the end of the siphon is 1.5 m lower than the bottom of the beaker. **Determine** the maximum height of the hill, H, that water can be siphoned without cavity occurring when the atmospheric pressure is 101.3 kPa and the vapor pressure of water at 15°C is 1.765 kPa (abs).



7. (15%) Water (1000 kg/m^3) flow through a horizontally placed pipe bend as shown in the below figure with constant a cross-sectional area of 0.01 m^2 throughout the pipe. The axial flow velocity in the pipe is maintained at 15 m/s. Assuming the absolute pressure at the entrance and exit of the pipe bend are 105.7 kPa (gage) and 63.7 kPa (gage) respectively, **calculate** the y-component of the anchoring force required to hold the pipe bend in place.



503302

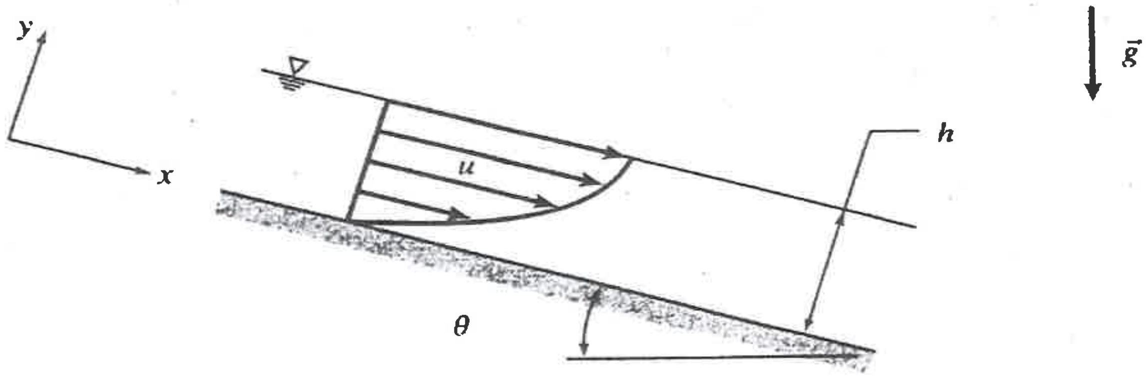
國立臺灣科技大學113學年度碩士班招生試題

系所組別：機械工程系碩士班丙組

科　　目：熱力與流力

（總分為100分；所有試題務必於答案卷內頁依序作答，否則不予計分）

8. (10%) Water flows down an inclined plane surface with an angle, θ, in a steady, fully developed laminar film of thickness h. Simplify the Navier-Stokes equations to **derive** the liquid velocity profile, u(y). Show your steps.



Navier – Stokes equations :

$$
\begin{cases}
\rho\left(\dfrac{\partial u}{\partial t}+u\dfrac{\partial u}{\partial x}+v\dfrac{\partial u}{\partial y}+w\dfrac{\partial u}{\partial z}\right)=-\dfrac{\partial p}{\partial x}+\rho g_x+\mu\left(\dfrac{\partial^2 u}{\partial x^2}+\dfrac{\partial^2 u}{\partial y^2}+\dfrac{\partial^2 u}{\partial z^2}\right)\\
\rho\left(\dfrac{\partial v}{\partial t}+u\dfrac{\partial v}{\partial x}+v\dfrac{\partial v}{\partial y}+w\dfrac{\partial v}{\partial z}\right)=-\dfrac{\partial p}{\partial y}+\rho g_y+\mu\left(\dfrac{\partial^2 v}{\partial x^2}+\dfrac{\partial^2 v}{\partial y^2}+\dfrac{\partial^2 v}{\partial z^2}\right)\\
\rho\left(\dfrac{\partial w}{\partial t}+u\dfrac{\partial w}{\partial x}+v\dfrac{\partial w}{\partial y}+w\dfrac{\partial w}{\partial z}\right)=-\dfrac{\partial p}{\partial z}+\rho g_z+\mu\left(\dfrac{\partial^2 w}{\partial x^2}+\dfrac{\partial^2 w}{\partial y^2}+\dfrac{\partial^2 w}{\partial z^2}\right)
\end{cases}
$$

9. (10%) The drag force, F, on a smooth sphere depends on the relative speed, V, the sphere diameter, D, the fluid density, ρ, and the fluid viscosity, μ. **Obtain** a set of dimensionless group that can be used to correlate experimental data. Show your steps.