KEY Exam #3

Question 1. Water flows through a garden hose that goes up a step 20.0 cm high. The cross-sectional area of the hose at the top of the step is half that at the bottom of the step. The speed of the water at the bottom of the step is 1.20 m/s. If the water pressure is 143 kPa at the bottom of the step, what is the pressure (in kPa) at the top of the step?

$$A_2 = \tfrac{1}{2} A_1$$

$$A_1 v_1 = A_2 v_2$$

$$A v_1 = \tfrac{1}{2} A_1 v_2$$

$$v_2 = 2 v_1 = 2.40 \text{ m/s}$$

$$P_1 + \rho g h_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \tfrac{1}{2}\rho v_2^2$$

$$P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \tfrac{1}{2}\rho v_2^2$$

$$P_2 = P_1 - \rho g h_2 + \tfrac{1}{2}\rho (v_1^2 - v_2^2)$$

$$P_2 = P_1 - \rho g h_2 - \tfrac{1}{2}\rho (v_2^2 - v_1^2) = 139 \text{ kPa}$$

(1)	143
(2)	337
(3)	101
(4)	210
(5)	139
(6)	530 132
(7)	198
(8)	20
(9)	51
(10)	141

MAKEUP $A_2 = \tfrac{1}{4} A_1$ $A_1 v_1 = A_2 v_2$ $v_2 = 4 v_1 = 4.8$

$P_2 = 132$ kPa

Question 2. A 0.980 kg block slides on a frictionless, horizontal surface with a speed of 1.32 m/s. The block encounters an unstretched spring with a spring constant of 245 N/m, How far (in meters) is the spring compressed before the block comes to rest?

$$E_0 = E_f$$

$$\tfrac{1}{2} m v^2 = \tfrac{1}{2} k x^2$$

$$x = v\sqrt{\frac{m}{k}}$$

(1)	0.0835
(2)	0.110
(3)	0.00528
(4)	0.00697
(5)	0.00264
(6)	0.00348
(7)	0.0418
(8)	0
(9)	0.222 0.3975
(10)	0.167

MAKE-UP. Calculate the period of one oscillation.

$$T = 2\pi\sqrt{m/k} = 0.3975$$

Question 3. When a 0.420 kg mass (m_1) is attached to a spring, it oscillates with a period of 0.350 s. If a second mass (m_2) is attached to the same spring (after removing mass m_1), it oscillates with a period of 0.700s. Find the mass of m_2 in kg.

(1) 0.105
(2) 135
(3) 0.210
(4) 7.52
(5) 16.5
(6) 1.68
(7) 5.26
(8) 0.419
(9) 1.32
(10) 2.39

$T_1 = 2\pi\sqrt{m_1/k}$

$T_2 = 2\pi\sqrt{m_2/k}$

$\frac{T_1}{T_2} = \sqrt{\frac{m_1}{m_2}}$ $\qquad m_2 = \left(\frac{T_2}{T_1}\right)^2 m_1$

ON MAKE-UP. WHAT is spring constant in N/m

$T_1 = 2\pi\sqrt{m_1/k}$ $\qquad k = \frac{4\pi^2 m_1}{T_1^2} = 135$

Question 4. A star of radius $R = 2.3 \times 10^8$ m rotatres with an angular speed $w = 2.4 \times 10^{-6}$ rad/s. If the star collapses to a radius of 20.0 km, find the stars final angular speed (in rad/s). Treat the star as if it were a uniform sphere and assume that no mass is lost as the star collapses.

(1) 0.028
(2) 0
(3) 1.81×10^{-16}
(5) 181
(6) 3.2×10^8
(7) 24
(8) 2.4×10^{-6}
(9) 2800
(10) 320

$L_0 = L_f$ $\qquad I = \frac{2}{5} M R^2$

$I_0 w_0 = I_f w_f$

$w_f = \frac{I_0}{I_f} w_0 = \left(\frac{R_0^2}{R_f^2}\right) w_0$

MAKE-UP $R_f = 26.5$ km

$w_f = \left(\frac{2.3 \times 10^5}{26.5}\right)^2 2.4 \times 10^{-6} \frac{rad}{s} = 181 \frac{rad}{s}$

Question 5. A 1.20 kg disk with a radius of 10.0 cm rolls without slipping. If the linear speed of the disk is 1.41 m/s, find the total kinetic energy of the disk in Joules.

$$KE = \tfrac{1}{2} m v^2 + \tfrac{1}{2} I \omega^2$$

$$I_{disk} = \tfrac{1}{2} m r^2 \qquad \omega = v/r$$

$$KE = \tfrac{1}{2} m v^2 + \tfrac{1}{2} \left(\tfrac{1}{2} m r^2\right) \frac{v^2}{r^2}$$

$$= \tfrac{1}{2} m v^2 + \tfrac{1}{4} m v^2 = \tfrac{3}{4} m v^2 = 1.99 \text{ J}$$

(1) 1.19
(2) 0.596
(3) 1.79
(4) 2.39
(5) 2.98
(6) 0.476
(7) ~~1.67~~ 1.69
(8) 0.396
(9) 1.59
(10) 1.44

DO MAKE-UP HOOP

$$KE = \tfrac{1}{2} m v^2 + \tfrac{1}{2} (m r^2) \frac{v^2}{r^2} = m v^2 =$$

$$= \tfrac{1}{2} m v^2 + \tfrac{1}{2} m v^2$$

2.39 J ~~1.99 J~~

Question 6. A 1200 kg car moving at 2.5 m/s is struck in the rear by a 2600 kg truck moving at 6.2 m/s. If the vehicles stick together after the collision, what is their speed immediately after colliding in m/s?

$$P_0 = P_f$$

$$m_1 v_{10} + m_2 v_{20} = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1 v_{10} + m_2 v_{20}}{m_1 + m_2} = 5.0$$

(1) 0.2
(2) 9.8
(3) 8.7
(4) 0.33
(5) 1.4
(6) ~~4.3~~ 4.2
(7) 6.8
(8) 20
(9) 5.0
(10) 2.5

DO MAKE-UP

1200 kg car at rest

$v_f = 4.2$

$v_{0_{car}} = 0$

706

Question 7. A piece of wood with density of ~~706~~ 800 kg/m^3 is tied with a string to the bottom of a water-filled flask. The wood is completely immersed and has a volume of 8.00×10^{-6} m^3. Find the tension in the string in Newtons.

(1) 0.055
(2) 0.13
(3) 0
(4) 0.023
(5) 0.16
(6) 0.34
(7) 0.093
(8) 0.93
(9) ~~0.046~~ 0.014
(10) 0.078

$\Sigma F_y = 0$

$F_B - T - mg = 0$

$T = F_B - mg = \rho_w V_{wood} g - \rho_{wood} V_{wood} g$

$T = V_{wood} g (\rho_{water} - \rho_{wood})$

$T = 0.023$

ON MAKE-UP

$\rho_{wood} = 800$

$V = 7.06 \times 10^{-4}$

$T = 0.014$

Question 8. A turntable for playing records has a moment of inertia of 5.2 kg m^2 and is rotating with an angular velocity of 36 rpm (revolutions per minute). A record, initially at rest, is dropped straight down onto the rotating turntable. The record and turntable rotate together at 33 rpm. Find the inertia of the record in kg m^2.

(1) 0.23
(2) 2.6
(3) 0
(4) ~~0.19~~ 0.13
(5) 5.7
(6) 0.32
(7) 0.081
(8) 0.47
(9) 5.1
(10) 10.0

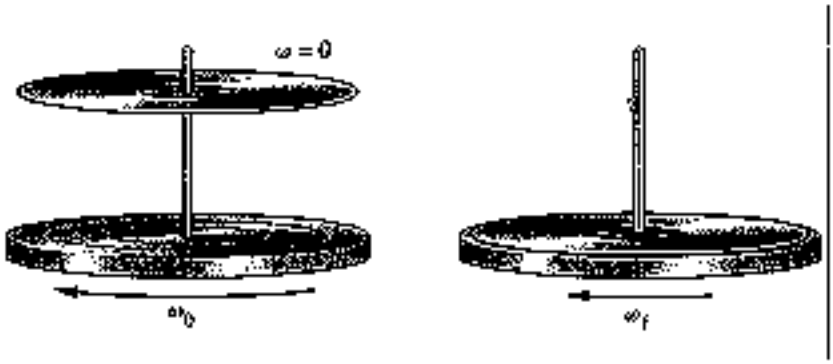
$L_0 = L_f$

$I_t \omega_{0t} = (I_t + I_r) \omega_f$

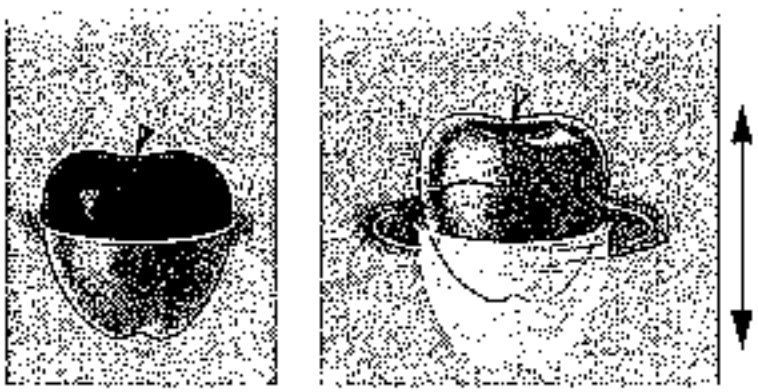
$I_r = I_t \left(\frac{\omega_{0t}}{\omega_f} - 1 \right)$

MAKE-UP $\omega_{0t} = 80$

$\omega_f = 78$ $I_r = 0.13$



For questions 9 and 10:
An apple floats in a barrel of water. If you lift the apple 2.0 cm above its floating level and release it, it bobs up and down with a period T=0.750 s. Assume upwards is the positive y direction.



Question 9. Assuming the motion is simple harmonic motion find the position of the apple for the time equal to T/4 in cm.

(1) -2.00
(2) 2.00
(3) 0
(4) -1.00
(5) 1.00
(6) -0.5
(7) 0.5
(8) -0.25
(9) 0.25
(10) 9.8

$x = A \cos \omega t$ $\quad \omega = \frac{2\pi}{T}$

$x = A \cos\left(\frac{2\pi}{T}\frac{T}{4}\right)$ $\quad t = T/4$

$x = A \cos\left(\frac{\pi}{2}\right) = 0$ $\quad A = 2.00\,cm$

OR MAKE-UP $t = T/2$

$x = A \cos\left(\frac{2\pi}{T}\frac{T}{2}\right) = A \cos\pi = -2.00\,cm$

Question 10. Assuming the motion is simple harmonic motion find the velocity of the apple for the time equal to T/4 in cm. (in cm/s)

(1) 0.25
(2) -12.0
(3) 12.0
(4) 4.0
(5) -4.0
(6) 14.5
(7) -14.5
(8) 0
(9) 16.8
(10) -16.8

$v = -A\omega \sin \omega t$ $\quad$ MAKE UP $t = T/2$

$v = -A\frac{2\pi}{T} \sin \frac{2\pi}{T}\frac{T}{2} = -A\frac{2\pi}{T} \sin \pi = 0$

EXAM. $t = T/4$

$v = -A\frac{2\pi}{T} \sin \frac{2\pi}{T}\frac{T}{4} = -\frac{2.00 \cdot 2\pi}{0.750}$

$= -16.8\,cm/s$