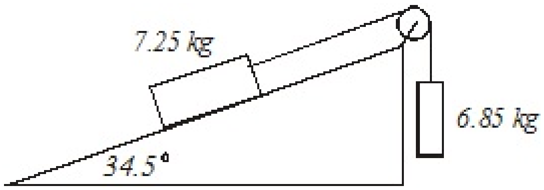
# Fluids



**WORKSHEET #3**

Name: ______________________

1. Find the acceleration of the system shown in the drawing if the coefficient of kinetic friction between the 7.25 kg mass and the plane is 0.295.




$w_{6.85}$ = 6.85 kg · 9.8 m/s$^2$ = 67.13 N
$w_{7.25}$ = 7.25 kg · 9.8 m/s$^2$ = 71.05 N
$F_{sys}$ = $m_{sys} \cdot a_{sys}$
$a_{sys}$ = $F_{sys}/m_{sys}$
= $(w_{6.85} - F_{fric} - F_{para7.25})$/(7.25 kg + 6.85 kg)
= (67.13 N - 0.295 · 71.05 N · cos 34.5° - 71.05 N · sin 34.5°)/14.10 kg
= **0.68179844 m/s$^2$**

2. A 50.0 kg telephone repairperson climbs up your basic tall power pole. She is carrying 8.15 kg of tools, meters, and peanut butter sandwiches. If she generates 0.815 hp, how much time does it take her to climb the 3.40 m tall pole?

0.815 hp · 746 W/hp = 607.99 W
P = W/t
t = W/P = (58.15 kg · 9.8 m/s$^s$ · 3.40 m)/607.99 W = 3.18682544 s = **3.19 s**

3. A golden coin has a mass of 15.0 grams. It is immersed in water. Find: (a) the volume it displaces, (b) the buoyant force exerted on it by the water, and (c) its apparent weight while it is dunked in the water.

a. $\rho = m/V$
V = m/ρ = 0.015 kg/19,300 kg/m$^3$ = 7.7720207x10$^{-7}$ m$^3$ = **7.77x10$^{-7}$ m$^3$ or 0.777 ml**
b. $F_b = \rho V g$ = 1000 kg/m$^3$ · 7.77x10$^{-7}$ m$^3$ · 9.8 m/s$^2$ = 0.00761658 N = **0.00762 N or 7.62 mN**
c. $w_{app} = w - F_b$ = 0.015 kg · 9.8 m/s$^2$ - 0.00761 N = 0.1393834 N = **0.139 N**

4. An 87.0 kg astronaut in space throws a 15.0 kg oxygen tank away from herself. If the recoil speed of the astronaut is 2.85 m/s, what was the velocity given to the oxygen tank?

$p_{astro} = p_{tank}$
$m_{astro} \cdot v_{astro} = m_{tank} \cdot v_{tank}$
$v_{tank} = m_{astro} \cdot v_{astro} / m_{tank}$ = 87.0 kg · 2.85 m/s / 15.0 kg = 16.53 m/s = **16.5 m/s**

**5.** An asteroid revolves around the sun at a distance of 6.35 x $10^{12}$ m. The asteroid's mass is 2.5 x $10^{8}$ kg and its radius is 55.34 x $10^{3}$ m. The Sun's mass is 1.99 x $10^{30}$ kg (a) What is its orbital velocity? (b) What is the period of its orbit (in days)?

a. $F_{centripetal} = F_{gravity}$

$m_{asteroid} \cdot a_{centripetal} = Gm_{asteroid}m_{sun}/r^2$

$m_{asteroid} \cdot v^2/r = Gm_{asteroid}m_{sun}/r^2$

$v = (Gm_{sun}/r)^{\frac{1}{2}} = (6.67\text{x}10^{-11}\ m^3/kg{\cdot}s^2 \cdot 1.99\text{x}10^{30}\ kg/6.35\text{x}10^{12}\ m)^{\frac{1}{2}}$

$= 4571.962$ m/s = **4570 m/s or 4.572 km/s**

b. $v = d/t$

$t = d/v = 2\pi r/v = 2\pi \cdot 6.35\text{x}10^{12}$ m / 4571.962 m/s = 8 726 718 792 s

8 726 718 792 s · 1 hr/3600 s · 1 d/24 hr = 101003.69 days = **101 000 days**

**6.** A 1.25 kg ball is shot straight up into the air. It reaches a height of 38.0 meters. As it reaches the highest point in its travel, a second ball, a 2.20 kg one, traveling horizontally at a speed of 22.5 m/s (at the instant of the collision) smacks into it – this ball rebounds straight back at a speed of 5.25 m/s. Okay, here's the stuff you get to calculate: (a) The initial speed of the first ball. (b) The velocity of the first ball after the collision. (c) The total energy of the first ball after the collision. (d) The horizontal distance the first ball travels from its launch point to where it hits the ground.

$t_0$ : instant after first ball is shot into air
$t_1$ : when first ball reaches vertical peak
$t_2$ : instant after 2 balls colllide
$t_3$ : instant before first ball lands on ground

a. $v_1^2 = v_0^2 + 2ad$

$v_0^2 = v_1^2 - 2ad = (0\ m/s)^2 - 2 \cdot (-9.8\ m/s^2) \cdot 38.0\ m = 744.8\ m^2/s^2$

$v_0 = 27.291024$ m/s = **27.3 m/s**

b. $p_{before} = p_{after}$

$m_A v_{A1} + m_B v_{B1} = m_A v_{A2} + m_B v_{B2}$

1.25 kg · 0 m/s + 2.20 kg · 22.5 m/s = 1.25 kg · $v_{A2}$ + 2.20 kg · (-5.25 m/s)

$v_{A2}$ = (2.20 kg · 22.5 m/s + 2.20 kg · 5.25 m/s)/1.25 kg = 48.84 m/s = **48.8 m/s**

c. TE= PE + KE = $mgh + \frac{1}{2}mv^2$

= 1.25 kg · 9.8 m/$s^2$ · 38.0 m + 0.5 · 1.25 kg · (48.84 m/s)$^2$ = 1956.341 J = **1960 J**

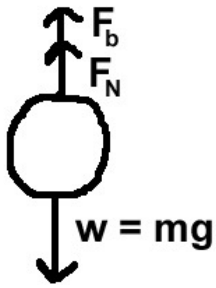
d. $v_1 = v_0 + at$

$t = (v_1 - v_0)/a$ = 27.3 m/s / 9.8 m/$s^2$ = 2.7857142857 s

$d = v \cdot t$ = 48.84 m/s · 2.7857142857 s = 136.0542857 m = **136 m**

**7.** A solid sphere has a radius of 15.0 cm and a mass of 1.05 kg. It sinks to the bottom of the ocean to a depth of 9 550 m. (a) Draw a FBD showing all the forces acting on the ball at this depth. (b) What is the pressure experienced by the ball at that depth? (c) What is the force exerted on the surface of the ball. (d) What is the buoyant force acting on the ball?

a.




b. $P = \rho gh = 1025\ kg/m^3 \cdot 9.8\ m/s^2 \cdot 9550\ m = 95929750\ Pa =$ **95 900 000 Pa or 95.9 MPa**

c. $P = F/A$

$F = P \cdot A = P \cdot 4\pi r^2 = 95{,}930{,}000\ Pa \cdot 4\pi \cdot (0.15\ m)^2 = 27123498\ N =$ **27 100 000 N or 27.1 MN**

d. $F_b = \rho Vg = \rho(4/3)\pi r^3 g$

$= 1025\ kg/m^3 \cdot 4/3\ \pi \cdot (0.15\ m)^3 \cdot 9.8\ m/s^2 = 142.00784\ N =$ **142 N**

**8.** The distance between two slits is 0.0500 mm and the distance to the screen is 2.50 m. Monochromatic light is incident on the slits. The spacing between the first-order and second-order bright fringes is 2.90 cm. Find (a) the wavelength of the light and (b) the frequency of the light.

a. $x_m = m\lambda L/d$

$\lambda = x_m \cdot d / mL = 0.0290\ m \cdot 0.0000500\ m / 1 \cdot 2.50\ m =$ **580. nm**

b. $c = f \cdot \lambda$

$f = c/\lambda = 3.00 \times 10^8\ m/s / 580 \times 10^{-9}\ m = 5.172414 \times 10^{14}\ Hz =$ **$5.17 \times 10^{14}$ Hz or 517 THz**

**9.** There's this here cylinder-shaped oil storage tank (say, 10.0 m diameter by 8.00 m high) with a 1.00 m high earthen dike running around it at 2.00 m from its base. Billy Bob has a joint of pipe (diameter of 10.0cm) in the bed of his pick'emup truck that sticks way out. He accidentally backs into the tank. He then pulls forward, leaving a hole in the tank from the pipe sticking into it when he backed up. The hole is 1.50 m from the bottom of the tank. Okay, here goes: (a) Does the oil shoot out over the dike? If so, how much oil will be lost this way? (b) How much oil will end up inside the dike? (c) How much oil, if any, will spill out when, and if, the dike area fills? Assume the tank is completely filled with oil and is vented (no vacuum).

a. $P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$ ($P_1$ and $P_2$ are both atmospheric)

$\rho g y_1 + \frac{1}{2}\rho v_1^2 = \rho g y_2 + \frac{1}{2}\rho v_2^2$ (choose $y_1$ (hole) to be "0")

$\frac{1}{2}\rho v_1^2 = \rho g y_2 + \frac{1}{2}\rho v_2^2$ (apx. $v_2$ to be VERY close to 0)

$\frac{1}{2}\rho v_1^2 = \rho g y_2$ (divide all by $\rho$)

$\frac{1}{2} v_1^2 = g y_2$ (tank top ($y_2$) is 6.50 m above hole)

$v_1^2 = 2 g y_2 = 2 \cdot 9.8\text{m/s}^2 \cdot 6.50\text{ m} = 127.4\text{ m}^2/\text{s}^2$

$v_1 = 11.29\text{ m/s}$

The top of the dike is 2.00 m away from the hole and 0.50 m lower than the hole. We can find the speed at which the oil will just hit the top of the dike and then solve for the height of the oil ($y_2$) that will provide that speed. Anything above that height will clear the top of the dike, anything at that height or below will land within the dike.

$x = \frac{1}{2}at^2$ (how much time is required for the fluid to drop ½ meter?)

$t = (2x/a)^{\frac{1}{2}} = 0.319\text{ s}$

$v = d/t = 2.00\text{ m}/0.319\text{ s} = 6.27\text{ m/s}$ (speed oil leaves and just hits top of dike)

$y_2 = v_1^2/2g = 2.0\text{ m}$ (when oil is 2.00 m above the hole, it no longer clears dike)

a. Everything from 6.50 m above hole (full tank) to 2.00 m above hole clears dike.
   $V = \pi r^2 h = \pi \cdot (5.00\text{ m})^2 \cdot 4.50\text{ m} = 353.4\text{ m}^3 =$ **353 m³ shoot over dike**

b. Potentially, the rest could end up in the dike if it's high enough.
   $V = \pi r^2 h = \pi \cdot (5.00\text{ m})^2 \cdot 2\text{ m} = 157.1\text{ m}^3 =$ **157 m³ lands in dike**

c. $V = V_{dike} - V_{tank} = \pi \cdot (7.00\text{ m})^2 \cdot 1\text{ m} - \pi \cdot (5.00\text{ m})^2 \cdot 1\text{ m} = 75.4\text{ m}^3$
   The dike area can only hold 75.4 m³ of oil, and 157.1 m³ will try to spill in.
   $V_{overflow} = V_{spillindike} - V_{dike} = 157.1\text{ m}^3 - 75.4\text{ m}^3 =$ **81.7 m³ overflows dike**