Physics 101 Sample Exam 3 Solutions

New Stuff

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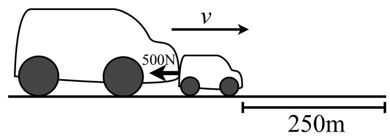
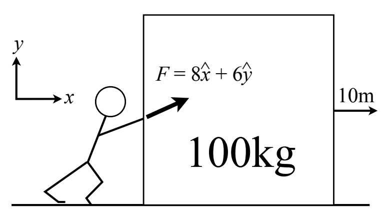
1. A large car pushes a small car for 250 m to the right. The **small car** exerts a force of $F = 500\,\text{N}$ on the large car. What work does the **small car** do on the large car?



The force and the motion are in opposite directions, so the work is negative.

$$W = -F\Delta r = -(500\,\text{N})(250\,\text{m}) = \boxed{-125\,\text{kJ}}$$

2. A force of $\vec{F} = 8\hat{x} + 6\hat{y}\,\text{N}$ is applied to a block, as it moves 10 m over the ground.



3 (a) **E** How much work is done on the block by that force?

A) $-100\,\text{J}$ **B)** $-80\,\text{J}$ **C)** $-20\,\text{J}$
D) $+100\,\text{J}$ **E)** $+80\,\text{J}$ **F)** $+20\,\text{J}$

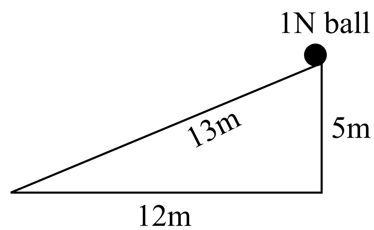
The motion is $\Delta\vec{r} = 10\hat{x}\,\text{m}$, and so

$$W = \vec{F}\cdot\Delta\vec{r} = (8\hat{x} + 6\hat{y})\cdot(10\hat{x}) = \boxed{80\,\text{J}}$$

2 (b) If the mass is 100 kg, starts at rest, and is sitting on a frictionless surface, what is its kinetic energy after it has been pushed 10 m?

The initial kinetic energy is zero, and 80 J of work is done on the block. Thus the final kinetic energy is $0 + 80 = \boxed{80\,\text{J}}$.

$\boxed{3}$ 3. **A** A ball with weight $mg = 1\,\mathrm{N}$ rolls down the ramp shown. What is the change in its potential energy once it reaches the bottom?



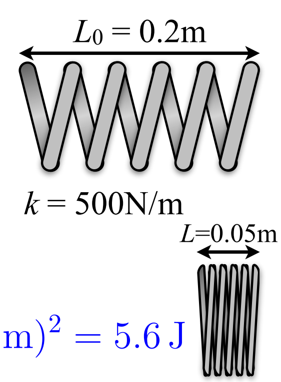
A) $-5\,\mathrm{J}$ **B)** $-12\,\mathrm{J}$ **C)** $-13\,\mathrm{J}$
D) $+5\,\mathrm{J}$ **E)** $+12\,\mathrm{J}$ **F)** $+13\,\mathrm{J}$

$$\Delta PE = mg\Delta h = (1\,\mathrm{N})(-5\,\mathrm{m}) = \boxed{-5\,\mathrm{J}}$$

$\boxed{3}$ 4. **C** $25\,\mathrm{W}$ is applied to a block for $5\,\mathrm{s}$. How much energy is provided?
A) $5\,\mathrm{J}$ **B)** $25\,\mathrm{J}$ **C)** $125\,\mathrm{J}$

A watt is a joule per second. $(25\,\mathrm{J/s})(5\,\mathrm{s}) = 125\,\mathrm{J}$.

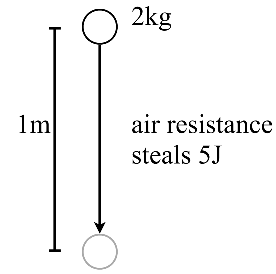
$\boxed{3}$ 5. **D** A spring has a relaxed length of $0.2\,\mathrm{m}$ and a spring constant of $500\,\mathrm{N/m}$. If the spring is compressed so that its length is $0.05\,\mathrm{m}$, what is the potential energy of the spring?



A) $-75\,\mathrm{J}$ **B)** $-5.6\,\mathrm{J}$ **C)** $0.63\,\mathrm{J}$
D) $5.6\,\mathrm{J}$ **E)** $25\,\mathrm{J}$ **F)** $75\,\mathrm{J}$

$$PE = \frac{1}{2}k(L - L_0)^2 = \frac{1}{2}(500\,\mathrm{N/m})(0.2\,\mathrm{m} - 0.05\,\mathrm{m})^2 = 5.6\,\mathrm{J}$$

$\boxed{4}$ 6. A 2 kg ball is dropped from the top of a building. It falls for 1 m, during which time air resistance does −5 J of work. How fast is the ball moving at the end of this motion?



Measure height from where the ball is released. The initial energy is

$$E_i = KE_i + PE_i = 0 + (2\,\mathrm{kg})(9.8\,\mathrm{m/s^2})(0) = 0$$

The final energy is

$$E_f = KE_f + PE_f = \frac{1}{2}(2\,\mathrm{kg})v_f^2 + (2\,\mathrm{kg})(9.8\,\mathrm{m/s^2})(-1\,\mathrm{m}) = v_f^2 - 19.6$$

Conservation of energy says

$$E_f = E_i + W \implies v_f^2 - 19.6 = 0 - 5 \implies v_f^2 = 19.6 - 5$$

$$\implies v_f = \sqrt{14.6} = \boxed{3.8\,\mathrm{m/s}}$$

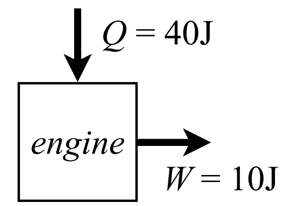
$\boxed{3}$ 7. __C__ Why is it impossible to create an engine with 100% efficiency?

A) It would violate conservation of energy.

B) It would be very slow.

C) It would result in a decrease of disorder (or entropy).

8. A heat engine takes in 40 J of heat every second and does 10 J of work.



$\boxed{3}$ (a) **C** What is the efficiency of this engine?

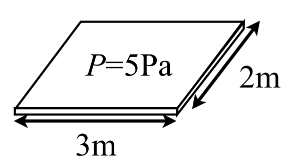
A) 10% **B)** 20% **C)** 25% **D)** 33% **E)** 75%

$\boxed{3}$ (b) **C** How much heat is expelled into the cold reservoir?

A) 10 J **B)** 20 J **C)** 30 J **D)** 40 J **E)** 50 J

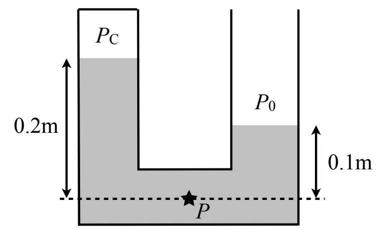
$\boxed{3}$ 9. **D** If I apply a 5 Pa pressure evenly on a 2 m by 3 m surface, what is the net force F that I (not the atmosphere) apply to the surface?

A) 0.83 N **B)** 1.2 N **C)** 25 N **D)** 30 N **E)** 6×10^5 N



$$F = PA = (5\,\mathrm{Pa})(6\,\mathrm{m}^2) = 30\,\mathrm{N}$$

10. A tube is closed on the left end, and open to the atmosphere on the right end. The tube is partially filled with water with density $\rho = 1000\,\mathrm{kg/m^3}$. Atmospheric pressure is $P_0 = 1.01 \times 10^5\,\mathrm{Pa}$.



$\boxed{3}$ (a) Suppose P is the pressure of the water at the star, 0.1 m below the level of the water in the right-hand tube. What is $P - P_0$? (This is known as the gauge pressure.)

$$P = P_0 + \rho g h \implies P - P_0 = \rho g h = (1000\,\mathrm{kg/m^3})(9.8\,\mathrm{m/s^2})(0.1\,\mathrm{m}) = \boxed{980\,\mathrm{Pa}}$$

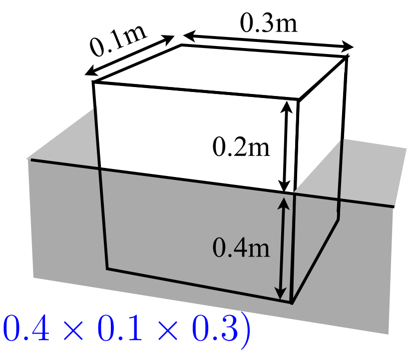
$\boxed{3}$ (b) **A** The pressure P_C of the air at the top of the left tube is

A) less than P_0 **B)** equal to P_0 **C)** greater than P_0

$\boxed{3}$ 11. **C** A block of wood has a mass of 500 kg and a density of $1200\,\mathrm{kg/m^3}$. It will float in which of the following fluids?

A) Formaldehyde ($812\,\mathrm{kg/m^3}$) **B)** Water ($1000\,\mathrm{kg/m^3}$)
C) Bromine ($3120\,\mathrm{kg/m^3}$) **D)** Formaldehyde and Water
E) Water and Bromine **F)** All of them **G)** None of them

12. The figure shows a block floating in water ($\rho = 1000\,\mathrm{kg/m^3}$). The block is 0.1 m deep, 0.3 m wide, and 0.6 m tall. The block extends above the water by 0.2 m and below by 0.4 m.



3 (a) Find the buoyancy force on the cube.

$$F_b = \rho g V_{\text{displaced}}$$

$$p = (1000\,\mathrm{kg/m^3})(9.8\,\mathrm{m/s^2})(0.4 \times 0.1 \times 0.3)$$

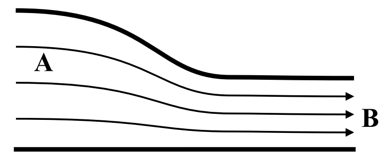
$$= \boxed{118\,\mathrm{N}}$$

3 (b) **C** Find the density of the cube. (Hint: you don't need the block's mass.)

A) $333\,\mathrm{kg/m^3}$ **B)** $500\,\mathrm{kg/m^3}$ **C)** $667\,\mathrm{kg/m^3}$ **D)** $1000\,\mathrm{kg/m^3}$

The density of the block is the density of the fluid, times the percentage of the block underwater (which is $0.4/0.6 = \frac{2}{3}$). So $\rho = 667\,\mathrm{kg/m^3}$.

13. Water is flowing through a narrowing pipe as shown.



$\boxed{2}$ (a) <u>**C**</u> At which end is the water flux Φ larger?

A) A **B)** B
C) The flux is the same at both ends

$\boxed{2}$ (b) <u>**B**</u> At which end is the water moving faster?

A) A **B)** B **C)** The speed is the same at both ends

$\boxed{2}$ (c) <u>**A**</u> At which end is the water pressure larger?

A) A **B)** B **C)** The pressure is the same at both ends