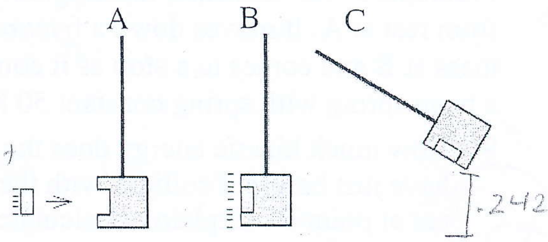
Honors Physics U7 – Q1 - Version B [redacted]

Unit 7 – Energy & Power SCORE: 32/42

Problems 1–3: A bullet (m_{bullet} m_1 = .05 kg) is shot into a block of wood ($m_{pendulum}$ m_2 = 3.95 kg) that hangs by a string from the ceiling. The bullet sticks into the block and they rise vertically 24.2 centimeters.



1. Which object exerts a greater force on the other? Why?

+3

They both have the same amount of force, just one is in moving w/ a greater velocity.

2. What is the speed of the block-bullet system in Picture **B** (after impact, but before the block-bullet begins to swing)?

+3

$K = U_g$

$\frac{1}{2} m v^2 = mgh$

$v = \sqrt{2gh}$

$v = \sqrt{2(9.8 m/s^2)(.242 m)}$

$\boxed{v_f = 2.178 m/s}$

3. What is the velocity of the bullet just before it hits the block (Picture **A**)?

+1

$K_{trans_i} = K_{trans_f}$

$\cancel{\frac{1}{2}m}(v_i)^2 = \cancel{\frac{1}{2}m} v_f^2$

$v = \sqrt{(v_f)^2}$

$\boxed{v_i = 2.178 m/s}$

$\cancel{\frac{1}{2}m_1 v_i^2 = \frac{1}{2} m_2 v_f^2}$

$\cancel{m_1 v_i^2 = m_2 v_f^2}$

$\cancel{v_i^2 = \frac{m_2 v_f^2}{m_1}}$

$\cancel{v_i = \sqrt{\frac{m_2 v_f^2}{m_1}}}$

$\cancel{v_i = \sqrt{\frac{(3.95 kg)(2.178 m/s)^2}{.05 kg}}}$

$\cancel{v_i = \sqrt{\frac{18.738 m^2}{.05 s^2}}}$

$\cancel{v_i = 19.36 m/s}$

$P_i = P_f$

$m_1 v_{1i} + \cancel{m_2 v_{2f}} = (m_1 + m_2) v_f$

$v_{1i} = \frac{(m_1 + m_2) v_f}{m_1}$

$v_{1i} = \frac{(.05 kg + 3.95 kg) 2.178}{.05 kg}$

$\boxed{v_i = 174.24 m/s}$

Problems 4–7: A 1000 kg car accelerates from rest to a speed of 60 m/s in 15 s.

4. How much energy is required to accelerate the car to this speed?

+3

$W = K_{trans}$

$W = \frac{1}{2} m v^2$

$\frac{1}{2}(1000 kg)(60 m/s)^2$

$\boxed{W = 1800000 J}$

5. What is the magnitude of the force acting on the car (assume constant acceleration)?

+1

$W = Fd$

$\frac{W}{d} = F$

$\frac{1800000 J}{900 m} = F$

$\boxed{2000 N = F}$

$v = \frac{x}{t}$ $x = vt$ $d = 900 m$

$F = ma$

$a = \frac{v}{t}$

$\frac{60 m/s}{15/s} = 4 m/s^2$

$F = 1000 kg (4 m/s^2)$

$\boxed{F = 4,000 N}$

6. What is the *average* power output of the car's motor during the 15 seconds?

+3

$P_{avg} = \frac{W}{\Delta t}$

$= \frac{1800000 J}{15 s}$

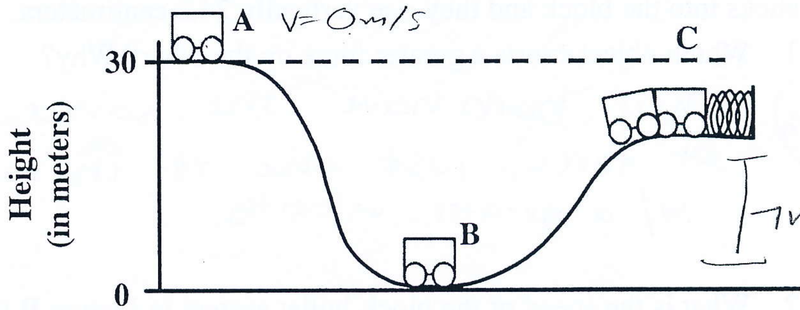
$\boxed{P_{avg} = 120000 W}$

Honors Physics

Unit 7 – Energy & Power

U7 – Q1 - Version B [redacted]

Problems 9–12: Consider the diagram representing a portion of an amusement park ride. A 100 kg car starts from rest at **A**. It moves down a *frictionless* track, collides *completely inelastically* with another car of equal mass at **B** and comes to a stop as it compresses a huge spring with spring constant 50 N/m at **C**.



9. How much kinetic energy does the first car have just before it collides with the second car at point **B**? Explain or calculate.

+3

$U_g = K_{trans}$

$mgh = \cancel{\frac{1}{2}mv^2}\ K_{trans}$

$(100\,kg)(9.8\,m/s^2)(30\,m) = K_{trans_i}$

$\boxed{29400\,J = K_{trans_i}}$

10. How fast are the cars moving immediately after point **B**?

+1

$K_{trans_i} = K_{trans_f}$

$K_i = \frac{1}{2}mv^2$

$\sqrt{\frac{2K_i}{m}} = v$

$\sqrt{\frac{2(29400\,J)}{200\,kg}} = v$

$\boxed{17.15\,m/s = v}$

$29400\,J = \frac{1}{2}mv^2$

$\frac{2(29400\,J)}{100\,m} = v^2$

$24.25\,m/s = v$

$\frac{m_1 v_1 + m_2 v_{2i}}{(m_1 + m_2)} = v_f$

$\frac{100\,kg\,(24.25\,m/s)}{200\,kg} = v_f$

$\boxed{12.12\,m/s = v_f}$

11. If the spring is located 7 m off the ground, how much elastic energy is stored in it after the cars come to a stop?

+3

$K_{trans} = U_g + U_{el}$

$\frac{1}{2}mv^2 = mgh + U_{el}$

$\frac{1}{2}mv^2 - mgh = U_{el}$

$\frac{1}{2}(200\,kg)(17.15\,m/s)^2 - (200\,kg)(9.8\,m/s^2)(7\,m) = U_{el}$

$29412.25\,J - 13720\,J = U_{el}$

$14700\,J - 13720\,J$

$\boxed{15692.25\,J = U_{el}}$

$\boxed{980\,J = U_{el}}$

12. How far does the spring compress?

3

$U_{el} = \frac{1}{2}kx^2$

$\sqrt{\frac{2U_{el}}{k}} = x$

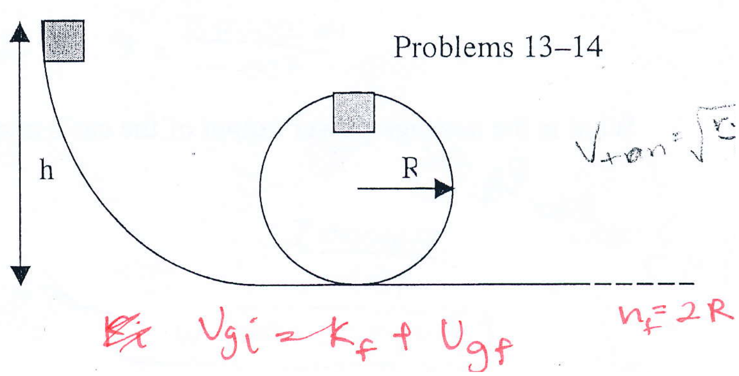
$\sqrt{\frac{2(15692.25\,J)}{50\,N/m}} = x$

$\boxed{x = 25.05\,m}$

$\boxed{x = 6.26\,m}$

Problems 13–14: A box of mass m is released on a track with a loop as indicated.

13. What is the minimum height the box must be released from so that it just makes it through the loop? Answer in terms of the appropriate variables.



$v_{top} = \sqrt{r}$

+1

$U_{gh} = UCM$

$mgh = \sqrt{\frac{r \cdot F_{rad}}{m}}$

$\cancel{K_i}\ U_{gi} = K_f + U_{gf}$

$h_f = 2R$

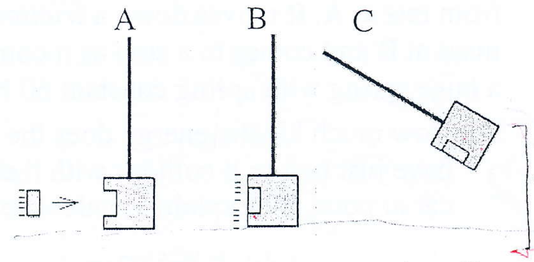
Honors Physics [redacted]

Unit 7 – Energy & Power

U7 – Q1 - Version A

SCORE: ~~33~~ 33/42

Problems 1–3: A bullet (m_{bullet} = .03 kg) is shot into a block of wood ($m_{pendulum}$ = 3.97 kg) that hangs by a string from the ceiling. The bullet sticks into the block and they rise vertically 24.2 centimeters.



h: 0

+3 1. Which object exerts a greater force on the other? Why?

The force exerted is the same because of Newton's 3rd Law:

$\vec{F}_{1 \text{ on } 2} = -\vec{F}_{2 \text{ on } 1}$

·1 2. What is the speed of the block-bullet system in Picture **B** (after impact, but before the block-bullet begins to swing)?

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$

$v = \sqrt{2gh}$

$v = \sqrt{2(9.8 N/kg)(.242 m)}$

$= 2.17$ m/s

~~$K_{tran} + U_{g1} + U_{e1} + W + E_{dis} = U_g$~~

~~$\frac{1}{2}mv^2 + mgh = \cancel{mgh_2}$ 0~~

~~$\frac{1}{2}\cancel{m}v^2 = -\cancel{m}gh$~~

~~$v = \sqrt{2(.03kg)(9.8 N/kg)(.08m) - (3.97kg)(9.8 N/kg)(}$~~

~~.031kg~~

~~v = √ .04704~~

3. What is the velocity of the bullet just before it hits the block (Picture **A**)?

+1

$m_1v_1 = m_f v_{1f} + m_2 v_{2f}$

$v = 290.67$ m/s

~~$K_{tran} = \frac{1}{2}mv^2$~~

$K_{tran} = \frac{1}{2}(.03kg)($

13.4864

.015

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}(.03kg)(v^2 = (4kg)(9.8 N/kg)(.242 m)$

$v = 29.98$ m/s

$\cancel{\frac{1}{2}}\cancel{m}v^2 = \left(\frac{mg\cancel{h}}{m}\right)(2)$ 0

$v^2 = 0$

$v = 0$ m/s

Problems 4–7: A 1500 kg car accelerates from rest to a speed of 55 m/s in 11 s.

+3 4. How much energy is required to accelerate the car to this speed?

$K_{tran} = \frac{1}{2}mv^2$

$K_{tran} = \frac{1}{2}(1500kg)(55 m/s)^2$

$K_{tran} = 2{,}268{,}750$ J

~~$F = ma$~~

~~$a = \frac{\Delta V}{\Delta t}$~~

~~$F = (1500kg)$~~

~~$a = \frac{55 m/s}{11 s}$~~

~~$F = (1500 kg)(5 N/kg)$~~

~~$F = 7500$ N~~

4537500

4112500

+3 5. What is the magnitude of the force acting on the car (assume constant acceleration)?

$F = ma$

$F = 1500kg (5 m/s^2)$

$F = 7500N$

$a = \frac{\Delta V}{\Delta t}$

$a = \frac{55 m/s}{11 s}$

$a = 5 m/s^2$

+3 6. What is the *average* power output of the car's motor during the 11 seconds?

$P = \frac{W}{s}$

$P = \frac{2{,}268{,}750 J}{11 s}$

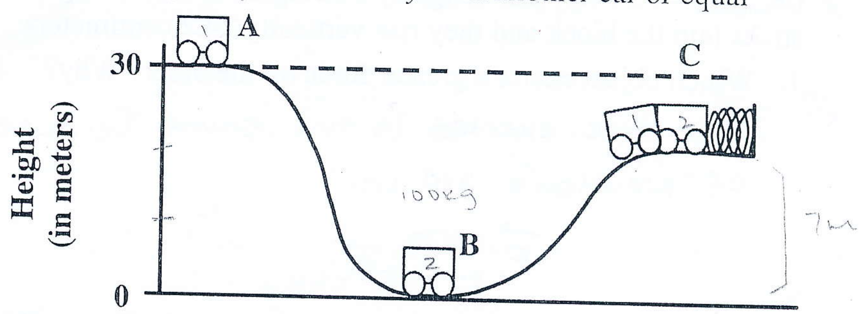
$P = 206{,}250$ W

Honors Physics

Unit 7 – Energy & Power

U7 – Q1 - Version A [redacted]

Problems 9–12: Consider the diagram representing a portion of an amusement park ride. A 100 kg car starts from rest at **A**. It moves down a *frictionless* track, collides *completely inelastically* with another car of equal mass at **B** and comes to a stop as it compresses a huge spring with spring constant 60 N/m at **C**.



9. How much kinetic energy does the first car have just before it collides with the second car at point **B**? Explain or calculate.

×3

$U_g = K_{tran}$

$mgh = K_{tran}$

$(100kg)(9.8 N/kg)(30m) = K_{tran}$

$K_{tran} = 29{,}400 J$

10. How fast are the cars moving immediately after point **B**?

+1

$\frac{1}{2}mv^2 = K_{tran}$

$\frac{200kg}{30m} = 2a$

$K_{tran} = \frac{1}{2}(200kg)(3.33 m/s)$

$a = 3.33$

$m_1V_{10} + m_2V_{20} = m_1V_{1f} + m_2V_{2f}$

$V_f = \frac{100kg(24.25 m/s) + 100kg(0 m/s)}{200 kg}$

$V_f = 12.125 m/s$

11. If the spring is located 7 m off the ground, how much elastic energy is stored in it after the cars come to a stop?

$K_{tran} = U_{el} + U_g$

$K_{tran} - U_g = U_{el}$

$\frac{1}{2}mv^2 - mgh = U_{el}$

$U_{el} = 981.56 J$

$U_{el} = \frac{1}{2}kx^2$

$mgh = \frac{1}{2}kx^2$

$\frac{2(200kg(9.8N/kg)(7m))}{60 N/m} = x$

$x = 21.4$

$U_{el} = \frac{1}{2}(60 N/m)(21.4 m)^2$

$U_{el} = 13738.8 J$

$2a(\Delta x)$

12. How far does the spring compress?

3

$W = \frac{1}{2}kx^2$

$Fd = \frac{1}{2}kx^2$

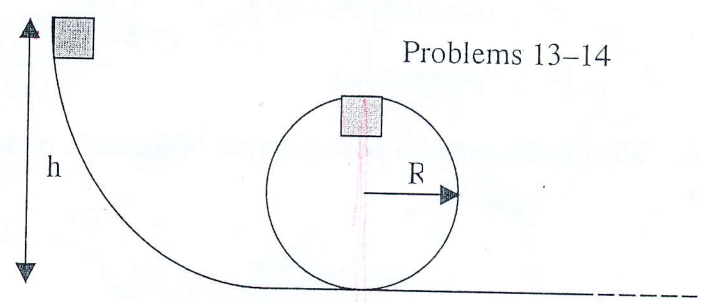
$\frac{2F}{k} = x$

$x = 5.55 m$

$F = ma$

$F = (100kg)(3.33 m/s^2)$

Problems 13–14: A box of mass m is released on a track with a loop as indicated.



13. What is the minimum height the box must be released from so that it just makes it through the loop? Answer in terms of the appropriate variables.

✓

$U_g = \frac{1}{2}mv^2 + U_{g_2}$ right equation

$mgh_1 = \frac{1}{2}m\left(\frac{F_{rad} \cdot r}{m}\right)^2 + mgh_2$

$h_1 = \frac{1}{2}(F_{rad} \cdot r)^2$

$g = \frac{V^2}{R}$

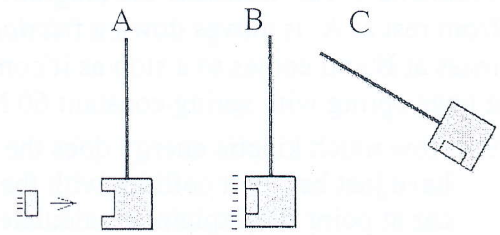
Honors Physics

Unit 7 – Energy & Power

U7 – Q1 - Version A [redacted]

SCORE: 32/42

Problems 1–3: A bullet (m_{bullet} = .03 kg) is shot into a block of wood ($m_{pendulum}$ = 3.97 kg) that hangs by a string from the ceiling. The bullet sticks into the block and they rise vertically 24.2 centimeters.



1. Which object exerts a greater force on the other? Why?

3

Neither object will evert a great force on the other because the forces in an interaction are equal in magnitude but opposite in direction.

2. What is the speed of the block-bullet system in Picture **B** (after impact, but before the block-bullet begins to swing)?

)

$K_o = K_f$

$\frac{1}{2}mv_o^2 = \frac{1}{2}mv_f^2$

$\frac{1}{2}(0.03kg)v_o^2 = \frac{1}{2}(4kg)v_f^2$

$0.015kg\, v_o^2 = 2kg\, v_f^2$

$\sqrt{0.0075 v_o^2} = v_f$

$\boxed{v = 2.18 m/s}$

$K_o = U_{gf}$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}(4kg)(v^2) = (4kg)(9.8 m/s^2)(0.242m)$

3. What is the velocity of the bullet just before it hits the block (Picture **A**)?

)

$K = \frac{1}{2}mv^2$

$\sqrt{\frac{2K}{m}} = v$

$\sqrt{\frac{2K}{0.03kg}} = v$

$\sqrt{(66.67kg)K} = v$

$m_1 v_{1o} + m_2 v_{2o} = m_1 \cancel{v_f} + m_2 v_f$

$m_1 v_o = v_f(m_1 + m_2) - m_2 v_{2o}$

$v_o = \frac{v_f(m_1 + m_2) - \cancel{m_2 v_{2o}}}{m_1}$

$v_o = \frac{2.18 m/s(0.03kg + 3.97kg)}{0.03kg}$

$\boxed{v_o = 290.67 m/s}$

Problems 4–7: A 1500 kg car accelerates from rest to a speed of 55 m/s in 11 s.

4. How much energy is required to accelerate the car to this speed?

3

$W = F\Delta x$

$W = 7500N(302.5m)$

$W = 2268750 J$

$a = \frac{\Delta v}{\Delta t}$

$a = \frac{55 m/s}{11s}$

$a = 5 m/s^2$

$F = ma$

$F = 7500N$

$\Delta x = \frac{1}{2}at^2 + \cancel{v_o t}$

$\Delta x = \frac{1}{2}(5 m/s^2)(11s)^2$

$\Delta x = 302.5m$

5. What is the magnitude of the force acting on the car (assume constant acceleration)?

3

$a = \frac{\Delta v}{\Delta t}$

$a = \frac{55 m/s}{11s}$

$a = 5 m/s^2$

$F = ma$

$F = (1500kg)(5 m/s^2)$

$F = 7500N$

6. What is the *average* power output of the car's motor during the 11 seconds?

3

$P_{av} = \frac{W}{\Delta t}$

$P_{av} = \frac{2268750J}{11s}$

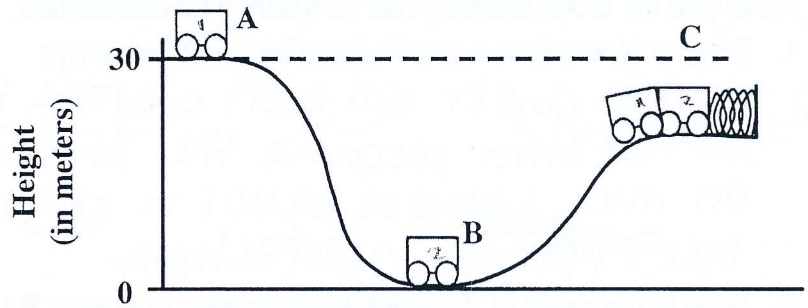
$P_{av} = 206250 W$

Honors Physics

Unit 7 – Energy & Power

U7 – Q1 - Version A [redacted]

Problems 9–12: Consider the diagram representing a portion of an amusement park ride. A 100 kg car starts from rest at **A**. It moves down a *frictionless* track, collides *completely inelastically* with another car of equal mass at **B** and comes to a stop as it compresses a huge spring with spring constant 60 N/m at **C**.



9. How much kinetic energy does the first car have just before it collides with the second car at point **B**? Explain or calculate.

$E_{go} = K_f$

$mgh = K_f$

$(100kg)(9.8 m/kg)(30m) = K_f$

$29400 J = K_f$

10. How fast are the cars moving immediately after point **B**?

① $K_f = \frac{1}{2}mv^2$ $\quad 17.15 m/s = v$

$\sqrt{\frac{2K_f}{m}} = v$

$\sqrt{\frac{2(29400J)}{200kg}} = v$

$m_1 v_{1o} + m_2 v_{2o} = m_1 v_f + m_2 v_f$

$m_1(v_{1o} + \cancel{v_{2o}}) = 2m v_f$

$\frac{v_{1o}}{2} = v$

$\frac{24.25 m/s}{2} = v$

$12.13 m/s = v_f$

$v_{1o} = \sqrt{\frac{2K}{m}}$

$v_{1o} = \sqrt{\frac{2(29400J)}{100kg}}$

$v_{1o} = 24.25 m/s$

11. If the spring is located 7 m off the ground, how much elastic energy is stored in it after the cars come to a stop?

① $U_{go} = U_{el}$

$mgh = U_{el}$

$(200kg)(9.8 m/kg)(7m) = U_{el}$

$13720J = U_{el}$

$K_{tran} = U_g + U_{el}$

$\frac{1}{2}mv^2 = mgh + U_{el}$

$\frac{1}{2}mv^2 - mgh = U_{el}$

$\frac{1}{2}(200kg)(12.13 m/s)^2 - (200kg)(9.8 m/kg)(7m) = U_{el}$

$14713.69J - 13720J = U_{el}$

$993.69J = U_{el}$

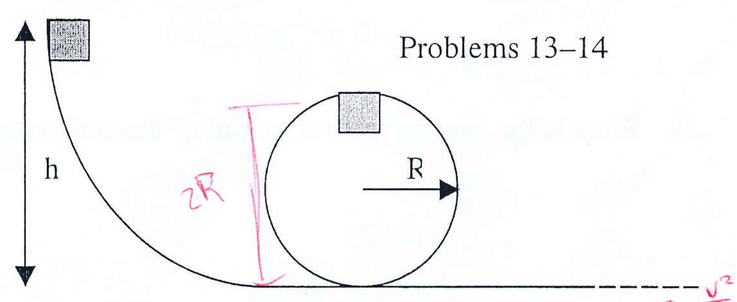
12. How far does the spring compress?

③ $U_{el} = \frac{1}{2}kx^2$ $\quad 21.39m = x$

$\sqrt{\frac{2U_{el}}{k}} = x$

$\sqrt{\frac{2(13720J)}{60 N/m}} = x$

Problems 13–14: A box of mass m is released on a track with a loop as indicated.



13. What is the minimum height the box must be released from so that it just makes it through the loop? Answer in terms of the appropriate variables.

① $U_{go} = K_f$ $\quad v_{tran}^2 = \frac{r \cdot \Sigma F_{net}}{m}$

$mgh = \frac{1}{2}mv^2$

$(R \cdot \Sigma F)$

$\Sigma F = ma$

$U_{go} = K_f + U_{gf}$

$g = \frac{v^2}{R}$

$v^2 = g$