Answer Key UP1 Sample Exam 2

Multiple choice

1. C
2. D
3. D
4. E
5. D
6. E
7. C
8. D
9. A
10. C
11. B
12. B
13. D

The answers to the first two free response questions are posted.

GOOD LUCK ON THE TEST!!!!

Show all work completely, legibly and in logical order, starting with basic concepts.

14. (20 points) Car A of mass 800 kg and car B of mass 1200 kg are headed towards each other as shown (top view). Immediately before impact, car A has a speed of 30.0 m/s and makes and angle of 40° with the x-axis as shown. Car B has a speed of 20.0 m/s and makes and angle of 75° with the y-axis as shown. After the collision, the cars stick together and move as one.

a) What is the velocity of the cars immediately after the collision, expressed in unit **vector (Cartesian) notation**. Clearly show all work for full credit.

onserve momentum

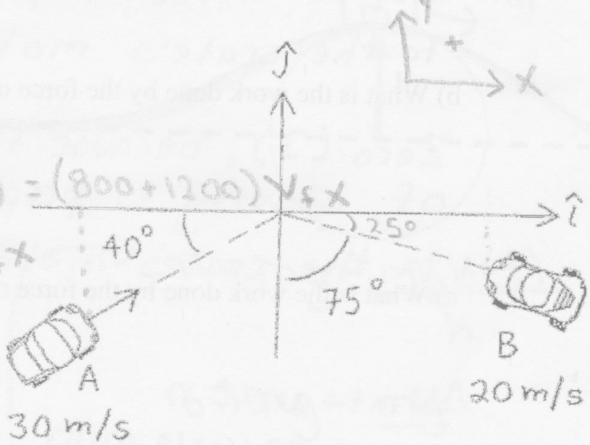
$m_a v_{aix} - m_b v_{bix} = (m_a + m_b) v_{fx}$

$800(30\cos 40) - 1200(20\sin 75) = (800+1200) v_{fx}$

$18385.07 - 23182.2 = 2000 v_{fx}$

$-4797.15 = 2000 v_{fx}$

$-2.39\ m/s = v_{fx}$



$m_a v_{aiy} + m_b v_{biy} = (m_a + m_b) v_{fy}$

$800(30\sin 40) + 1200(20\cos 75) = (800+1200) v_{fy}$

$15426.9 + 6211.66 = 2000 v_{fy}$

$21638.56 = 2000 v_{fy}$

$10.82 = v_{fy}$

$\vec{v}_f = (-2.39\hat{i} + 10.82\hat{j})\ m/s$

b) Is the collision elastic or inelastic? Justify you answer with some sort of calculation.

use conservation of energy

$m_a v_{ai}^2 + \frac{1}{2} m_b v_{bi}^2 = \frac{1}{2}(m_a + m_b) v_f^2$

$800)(30)^2 + \frac{1}{2}(1200)(20)^2 = \frac{1}{2}(800+1200)\left(\sqrt{-2.39^2 + 10.82^2}\right)^2$

$0000 + 240000 = 1000(11)^2$

$00000 J \neq 121000 J$

he collision is inelastic

Knowns

m = 15 kg

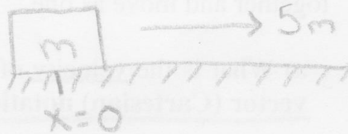
$\mu_k = 0.230$

$F = (80 - 10x)$ N

$v_i = 0$ m/s

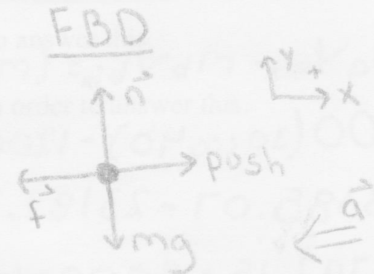
$\Delta x = 5$ m

15. (20 points) A crate of mass 15 kg is on a level floor that has a coefficient of kinetic friction of 0.230. A person is pushing the crate across the floor by applying a force parallel to the ground. They are getting tired as they push so the force they exert is given by F = (80 – 10x) N, where x = 0 is the starting position. They push the crate from rest a total of 5.0 m. **Show work for your answers below, or justify them with correct physics reasoning.**



a) What is the work done by the normal force?

Zero (J), because the normal force is perpendicular to the crate's motion.



b) What is the work done by the force of gravity?

Zero (J), because the force of gravity is perpendicular to the crate's motion.

c) What is the work done by the force of friction?

$\Delta U_{int} = \mu_k n d$

$= .23(15)(9.8)(5)$

$= 169.05$ J

$W = -\Delta U_{int}$

$W = -169.05$ J

d) What is the work done by the person's pushing force?

$W = \int F \cdot dx$

$= \int_0^5 80 - 10x \, dx$

$= 8x - \frac{1}{2}(10)x^2 \Big|_0^5$

$= 80(5) - 5(5)^2$

$W = 275$ J

e) What is the speed of the block at 5.0 m?

$\Sigma W = \Delta KE$

$\Sigma W = KE_f - KE_i$

$\Sigma W = \frac{1}{2}mv_f^2 - \frac{1}{2}v_i^2$

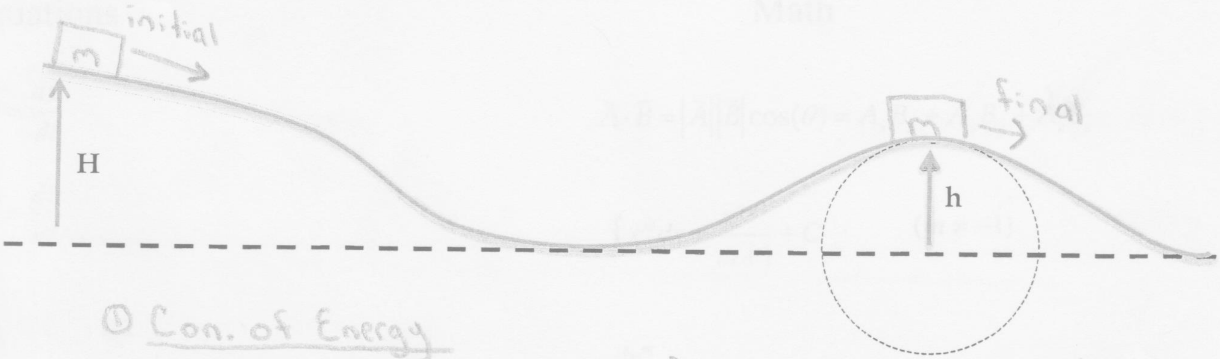
$275 - 169.05 = \frac{1}{2}(15)v_f^2 - \frac{1}{2}(15)0^2$

$105.95 = 7.5 v_f^2$

$14.13 = v_f^2$

3.76 m/s $= v_f$

16. (20 points) A block of mass m starts from rest at the top of a frictionless hill of height H. It slides down the hill and then over another hill of height h as shown. The top of the second smaller hill can be modeled as part of a circle with radius h. If $H = 5h/4$, what is the normal force that the track exerts on the block when it is at the top of the second hill? Express your answer in terms of m and g. If any part of your solution involves a free-body diagram, it must be clearly shown.



nowns
= 0 m/s
= m kg
$\frac{5}{4}h$

① Con. of Energy

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

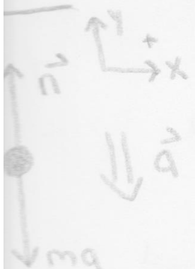
$\frac{5}{4}gh = \frac{1}{2}v^2 + gh$

$\frac{1}{4}gh = \frac{1}{2}v^2$

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

Newton's 2nd + Circular motion

BD



$\sum F_x = 0\,N$

$\sum F_y = n - mg = -ma$

$n - mg = -m\frac{v^2}{r}$

$n = -m\frac{v^2}{r} + mg$

*use v^2 from part ①

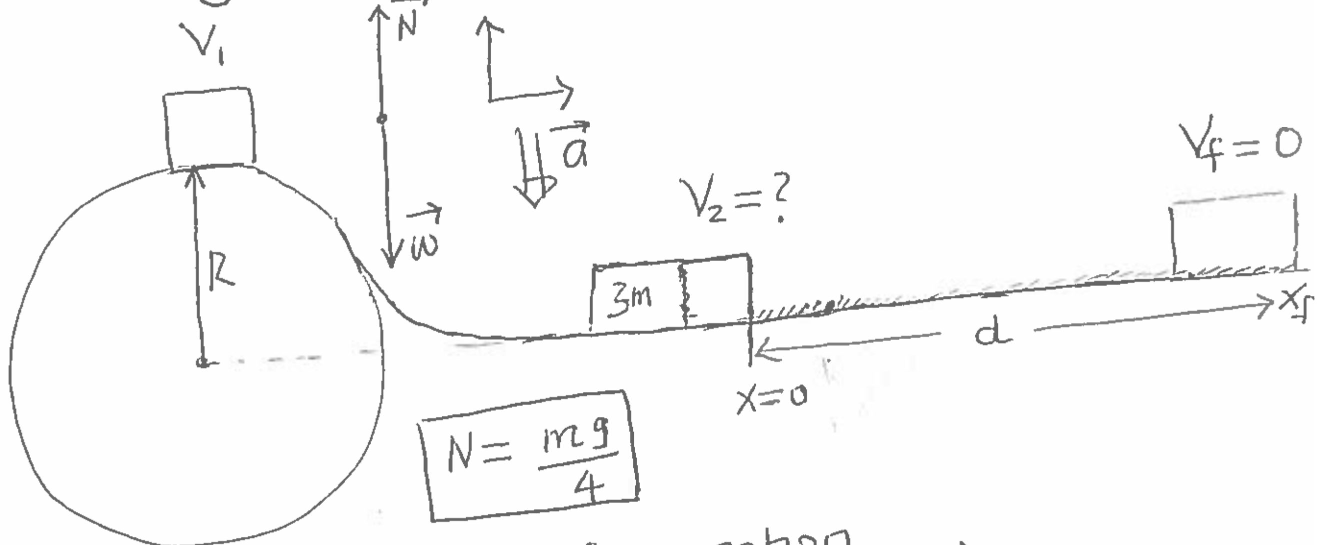
$n = mg - \frac{mgh(\frac{1}{2})}{h}$

$n = mg - \frac{mg}{2}$

$n = \frac{1}{2}mg$

* n is in N

Long Question – Show work.



$$N = \frac{mg}{4}$$

Find V_1 from N2L + Circular motion

$$\sum \vec{F_y} = m\vec{a_y}; \quad N - mg = m\left(\frac{-V_1^2}{R}\right)$$

$$\frac{mg}{4} - mg = -\frac{m}{R}V_1^2 \quad \text{or} \quad +\frac{3}{4}\cancel{m}g = +\frac{\cancel{m}}{R}V_1$$

$$V_1^2 = \frac{3}{4}Rg$$

Now use energy conservation to find the speed of m, just before colliding with 2m.

Apply energy Conservation with top of hill as "Initial" and bottom of hill as "final".

$$K_I + U_I = K_f + U_f + \Delta U_{int}$$

$$\frac{1}{2}mV_1^2 + mgR = \frac{1}{2}mV^2 + 0 + 0$$

$$\frac{1}{2}mV^2 = \frac{1}{2}mV_1^2 + mgR$$

$$\frac{1}{2}V^2 = \frac{1}{2}V_1^2 + gR$$

$$V^2 = V_1^2 + 2gR = \frac{3}{4}gR + 2gR$$

$$V^2 = \frac{11}{4}gR \quad \text{or} \quad V = \sqrt{\frac{11}{4}gR}$$

V = speed of block of mass "m" just before colliding with "2m"

V_2 – Velocity of "3m" soon after collision.

→ Use linear momentum conservation to find V_2

$$\sum \vec{P}_{fx} = \sum \vec{P}_{ix}$$

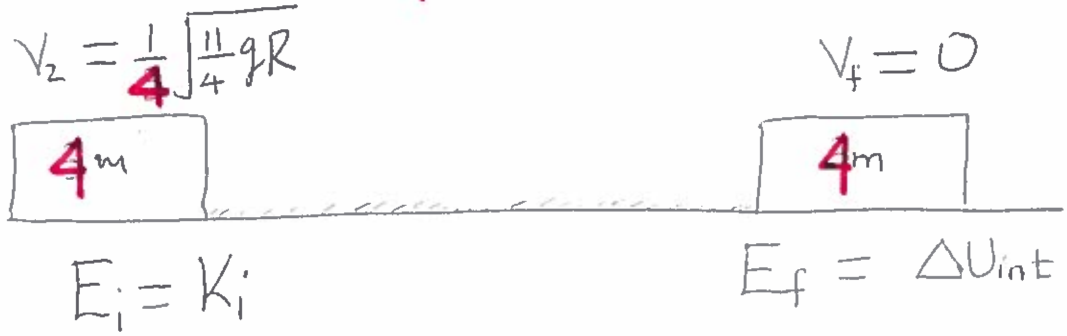
$V_{2x} = V_2$

$V_{ix} = V$

$$(m_1 + m_2)V_{2x} = m_1 V_{ix} + 0$$

(m_1 = m; m_2 = 3m)

$$V_2 = \frac{m}{4m} \cdot V = \frac{1}{4}\sqrt{\frac{11}{4}gR}$$



$$\frac{1}{2} \cancel{m} V_2^2 = \mu_k \cancel{m} g d$$

$$d = \frac{V_2^2}{2 \mu_k g} = \frac{\frac{1}{16} \cdot \frac{11}{4} \cdot gR}{2 \mu_k g} = \frac{11 R}{2(16)(4) \mu_k}$$

$$\boxed{d = \frac{11}{128} \frac{R}{\mu_k}}$$

$$d = \frac{11}{128} \frac{R}{\mu_k}$$