Section instructor ____________________ ***Section number*** __________

Last/First name A. DANYLOV

Last 3 Digits of Student ID Number: __________

Show all work. Show all formulas used for each problem prior to substitution of numbers. Label diagrams and include appropriate units for your answers. *You may use an alphanumeric calculator during the exam as long as you do not program any formulas into memory. By using an alphanumeric calculator you agree to allow us to check its memory during the exam. Simple scientific calculators are always OK!*

A formula sheet is attached to the Back of this examination

Be Prepared to Show your Student ID Card

Score on each problem:

1. (30) ____

2. (20) ____

3. (20) ____

4. (20) ____

Total Score (out of 90 pts) ____

1. Conceptual Questions

(30 point) Put a circle around the letter that you think is the best answer.

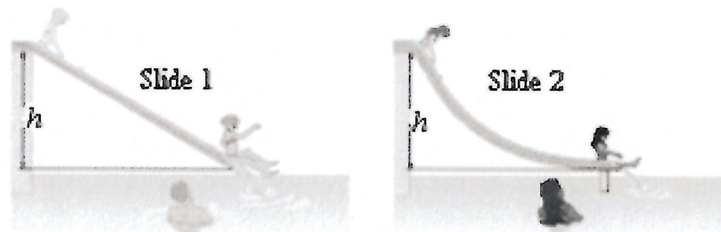
1.1. (6pts) Swimmers at a water park have a choice of two frictionless water slides as shown in the figure. Although both slides drop over the same height, h, slide 1 is straight while slide 2 is curved, dropping quickly at first and then leveling out. How does the speed v_1 of a swimmer reaching the end of slide 1 compares with v_2, the speed of a swimmer reaching the end of slide 2?

A) $v_1 > v_2$

B) $v_1 < v_2$

C) $v_1 = v_2$

D) No simple relationship exists between v_1 *and* v_2 *because we do not know the curvature of slide 2.*



1.2. (6pts) An object is under the influence of a force as represented by the force vs. position graph in the figure. What is the work done as the object moves from **4 m** to **12 m**?

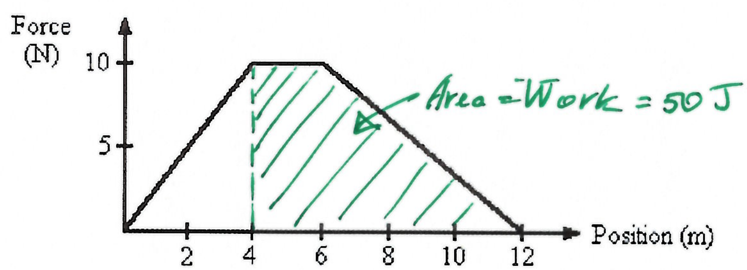
A) 20 J

B) 30 J

C) 0 J

D) 50 J

E) None of the above



1.3.(6pts) The work W_0 accelerates a car from 0 to v_0.

How much work (in terms of W_0) is needed to accelerate the car from v_0 to $3v_0$?

A) $2W_0$

B) $3W_0$

C) $6W_0$

D) $8W_0$

E) $9W_0$

$$W_0 = \Delta K = \frac{m}{2}(v_0^2 - 0^2) = \frac{m}{2}\cdot v_0^2$$

$$W = \Delta K = \frac{m}{2}((3v_0)^2 - v_0^2) = 8\left(\frac{m v_0^2}{2}\right) = 8\cdot W_0$$

1.4. (6pts) Two men, Tom and Jerry, push against a wall of a building. Jerry stops after 10 min, while Tom is able to push for 5.0 min longer. Compare the work they do?

A) Both men do positive work, but Tom does 75% more work than Jerry.

B) Both men do positive work, but Tom does 50% more work than Jerry.

C) Both men do positive work, but Jerry does 50% more work than Tom.

D) Both men do positive work, but Tom does 25% more work than Jerry.

E) Neither of them does any work.

$W = \vec{F} \cdot \vec{s}$, $W = 0$, since $s = 0$ (wall does not move)

1.5. (6pts) Calculate the dot product of the vectors in the figure if A=4 and B=2.

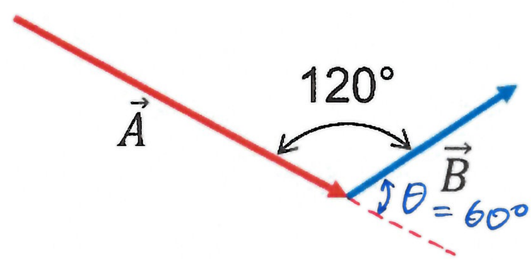
A) 8

B) -8

C) 4

D) -4

E) 2

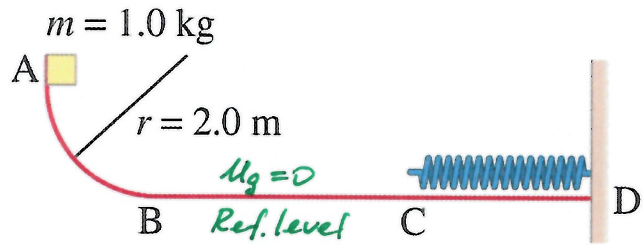


$\vec{A} \cdot \vec{B} = AB\cos\theta = 4 \cdot 2 \cdot \underbrace{\cos 60°}_{=1/2} = 4$

Problem 2. (20 pts)

Consider the track shown in the figure. The section AB is one quadrant of a circle of radius 2.0 m and is frictionless. The section B to D is a horizontal and also frictionless. A block of mass 1.0 kg is released from rest at A. After sliding on the track, it compresses the spring by 0.20 m. (use the energy approach).

a) (2 pts) Write down a general expression of a physical principle you use.
b) (1 pt) If you use gravitational potential energy, show a reference level
c) (7 pts) Find the velocity of the block at point C.
d) (10 pts) Find the spring constant k for the spring.

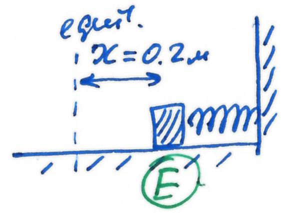


a) Conserv. of mech. energy

$$\boxed{E_A = E_C}$$

c) $\overset{0,\ v_A = 0}{\cancel{K_A}} + U_A = K_C + \overset{0,\ \text{Ref. level}}{\cancel{U_C}}$

$$\cancel{m} g r = \frac{1}{2}\cancel{m} v_C^2 \Rightarrow v_C = \sqrt{2 \cdot g \cdot r} = \sqrt{2 \cdot 9.8\,\text{m/s}^2 \cdot 2.0\,\text{m}} = 6.26\,\text{m/s}$$



d) $E_A = E_E$

$$\overset{0}{\cancel{K_A}} + U_{gA} = \overset{0}{\cancel{K_E}} + \overset{0,\ \text{Ref. level}}{\cancel{U_{gE}}} + U_{spE}$$

$$mgr = \frac{1}{2} \cdot k \cdot x^2$$

$$\left\| k = \frac{2mgr}{x^2} \right\| = \frac{2 \cdot 1.0\,\text{kg} \cdot 9.8\,\text{m/s}^2 \cdot 2.0\,\text{m}}{(0.2\,\text{m})^2} = 980\,\frac{\text{N}}{\text{m}}$$

Problem 3. (20 pts)

(*Use the work-kinetic energy principle to solve the problem*) Starting from rest, a box of mass $m=5.0\ kg$ is pushed up a frictionless slope of angle $\theta=20°$ by a horizontal force of magnitude $F=25\ N$. The height of the slope above the bottom is $h=2.0\ m$.

a) (4 pts) Draw a free-body diagram of all the forces acting on the box and show a displacement vector.

b) (1 pts) Write down a general expression of work done by a constant force.

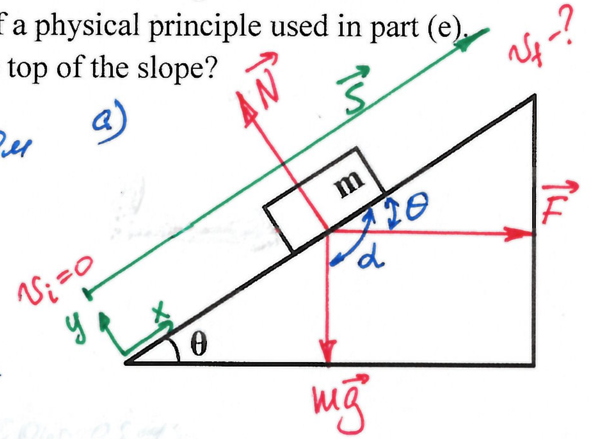
c) (7 pts) Determine works done by each of the forces acting on the box.

d) (2pts) Write down a general expression of a physical principle used in part (e).

e) (6 pts) What is the speed of the box at the top of the slope?

Given: $m=5.0\,kg,\ \theta=20°,\ F=25N,\ h=2.0m$
no friction

a)



b) $W=\vec{F}\cdot\vec{s}=Fs\cos\theta$

c) $W_N=\vec{N}\cdot\vec{s}=Ns\cancel{\cos\frac{\pi}{2}}^{0}=0$

$W_g=mg\,s\cdot\cos\alpha=mgs\underbrace{\cos(90°+\theta)}_{=-\sin\theta}=$

$=-mgs\cdot\sin\theta=-mgh=-5.0kg\cdot9.8m/s^2\cdot2.0m=-98\ J$

$W_F=\vec{F}\cdot\vec{s}=Fs\cos\theta=\left\|s=\frac{h}{\sin\theta}\right\|=F.\frac{h\cdot\cos\theta}{\sin\theta}=\frac{F\cdot h}{\tan\theta}=\frac{25N\cdot2.0m}{\tan20°}=137.37\ J$

d) $\boxed{W_{net}=\Delta K}$ Work-KE principle

$\Delta K=K_f-\cancel{K_i}^{0}=\cancel{W_N}^{0}+W_g+W_F$

$\frac{1}{2}mv_f^2=W_g+W_F\ \Rightarrow \left\| v_f=\sqrt{\frac{2}{m}(W_g+W_F)}\right\|$

$v_f=\sqrt{\frac{2}{5.0kg}(-98J+137.37J)}=3.97\ m/s$

Problem 4 (20 pts).

(Use the <u>energy conservation with nonconservative forces (losses)</u> to solve the problem)
In the figure, a block of mass m is moving along the horizontal frictionless surface with a speed of 5.70 m/s. If the slope is 11.0° and the coefficient of kinetic friction between the block and the incline is 0.260,

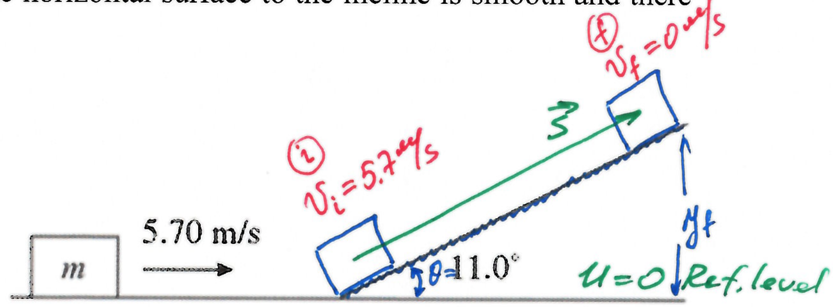
a) (2 pts) write down a general expression of a physical principle you use;
b) (1 pt) if you use gravitational potential energy, show a reference level;
c) (17 pts) how far does the block travel up the incline?

(Assume that the transition from the horizontal surface to the incline is smooth and there are no losses in energy).

Given: $v_i = 5.7\ m/s$; $v_f = 0\ m/s$

$\theta = 11°$; $\mu = 0.260$

Find: s - ?



a) $\boxed{E_f = E_i + W_{nc}}$

$$\cancelto{0}{K_f} + U_f = K_i + \cancelto{0}{U_i} + W_{fr}$$

$$U_f = mg \cdot y_f = mg \cdot s \cdot \sin\theta$$

$$W_{fr} = \vec{f_k} \cdot \vec{s} = \left\| \begin{matrix} f_k = \mu N = \\ = \mu \cdot mg\cos\theta \end{matrix} \right\| = f_k s \cos \overset{=-1}{180°} = -\mu mg \cdot s \cdot \cos\theta$$

$$\cancel{mg}\, s \cdot \sin\theta = \frac{1}{2}\cancel{m} v_i^2 - \mu \cancel{mg}\, s \cdot \cos\theta$$

$$s \cdot g \cdot (\sin\theta + \mu \cdot \cos\theta) = \frac{v_i^2}{2}$$

$$\left\| s = \frac{v_i^2}{2 \cdot g(\sin\theta + \mu \cdot \cos\theta)} \right\| = \frac{(5.7\ m/s)^2}{2 \cdot 9.8\ m/s^2 \cdot (\sin 11 + 0.260 \cdot \cos 11°)} = 3.7\ m$$