Group Number		Name		Type
List Number		Surname		A
Student ID		Signature		
e-mail				

ATTENTION: There is normally only one correct answer for each question and each correct answer is equal to 1 point. Only the answers on your answer sheet form will be evaluated. Please be sure that you have marked all of your answers on the answer sheet form by using a pencil (*not* pen).

1. The moment of inertia of a thin homogeneous disc rotating about its axis of symmetry, perpendicular to the plain of disc is given as I. One third is cut and paste as shown in figure. What is the moment of inertia of the obtained object with respect to the same rotation axis?

(a) $3I/2$ (b) $I/3$ (c) $2I/3$ (d) $4I/9$ (e) I

Questions 2-5

The potential energy of a particle is given by $U(x,y) = \frac{1}{4}(1-x^2)^2 + \frac{1}{2}y^2 + \frac{1}{2}x^2y^2$ in joules.

2. Find the components of the force acting on the particle in N.
(a) $F_x = \frac{1}{4}(1-x^2)^2 + \frac{1}{2}x^2y^2$, $F_y = \frac{1}{2}y^2 + \frac{1}{2}x^2y^2$
(b) $F_x = (1-x^2)x - xy^2$, $F_y = -y(1+x^2)$
(c) $F_x = -(1-x^2)x$, $F_y = 0$
(d) $F_x = -(1-x^2)x - xy^2$, $F_y = y(1+x^2)$
(e) $F_x = (1-x^2)x$, $F_y = 0$

3. At which position (in meters) given below, the particle is in equilibrium along the y-axis?
(a) $y = \sqrt{1-x^2}$ (b) $y = -\sqrt{1-x^2}$ (c) $x = -1$ (d) $x = 0$ (e) $y = 0$

4. What is F_x (in Newton) when the particle is in equilibrium along the y-axis?
(a) $F_x = (1-x^2)x$ (b) $F_x = \frac{1}{4}(1-x^2)^2$ (c) $F_x = 0$ (d) $F_x = -(1-x^2)x$ (e) $F_x = \frac{1}{2}y^2$

5. What is the total work done on the particle when it moves from the initial position $\{x,y\} = \{0\text{m}, 0\text{m}\}$ to the final position $\{x,y\} = \{1\text{m}, 0\text{m}\}$?
(a) 0 (b) 1/4 J (c) -1/4 J (d) -2/3 J (e) 2/3 J

6. Which of the following is always correct?
(a) $\sum \vec{F}_{\text{ext}} = \frac{\mathrm{d}\vec{p}}{\mathrm{d}t}$ (b) $\sum \vec{F}_{\text{int}} = m\vec{a}$ (c) $\sum \vec{F}_{\text{int}} = \frac{\mathrm{d}\vec{p}}{\mathrm{d}t}$ (d) $\sum \vec{F}_{\text{ext}} = m\vec{a}$ (e) $m\vec{a} = -\frac{\mathrm{d}m}{\mathrm{d}t}\vec{v}$

7. Various bodies at rest are left from the top of a frictionless inclined plane. In what order will these bodies reach the bottom of the inclined? SS=Solid sphere, TS=Thin-walled hollow sphere, SC=Solid cylinder, TC=Thin-walled hollow cylinder.
(a) SC,SS,TC,TS (b) SS,SC,TS,TC (c) All at the same time (d) SS,TS,SC,TC (e) SC,TC,SS,TS

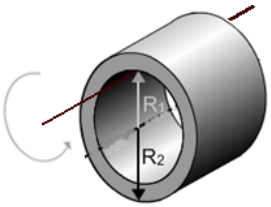
Questions 8-9

A solid cylinder rolls without slipping down a ramp, which is inclined at an angle β to the horizontal. Direction of rolling is parallel to the inclination. M is the mass and R is the radius of the cylinder, and the moment of inertia of a disc with mass M and radius R with respect to the axis of symmetry is $I = \frac{1}{2}MR^2$.

8. What is the cylinder's acceleration a_{cm} along the ramp?
(a) $a_{\text{cm}} = \frac{5}{7}g\cos\beta$ (b) $a_{\text{cm}} = \frac{5}{7}g\sin\beta$ (c) $a_{\text{cm}} = \frac{2}{3}g\sin\beta$ (d) $a_{\text{cm}} = g\sin\beta$ (e) $a_{\text{cm}} = \frac{2}{3}g\cos\beta$

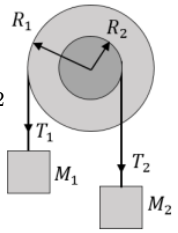
9. What is the magnitude of the friction force f on the cylinder?
(a) $f = \frac{2}{7}Mg\sin\beta$ (b) $f = \frac{1}{3}Mg\cos\beta$ (c) $f = 0$ (d) $f = \frac{1}{3}Mg\sin\beta$ (e) $f = \frac{2}{7}Mg\cos\beta$

10. What is the kinetic energy of an hollow cylinder of mass M rotating with an angular speed ω about the axis passing parallel through it's inner wall as shown in figure? $R_2 = 2R$ is the radius of the outer wall and $R_1 = R$ is the radius of the inner wall (empty part) of the hollow cylinder.
(a) $\frac{9}{8}MR^2\omega^2$ (b) $\frac{5}{4}MR^2\omega^2$ (c) $\frac{7}{4}MR^2\omega^2$ (d) $\frac{17}{4}MR^2\omega^2$ (e) $\frac{1}{2}MR^2\omega^2$



Questions 11-13

A winch has a moment of inertia I passing throughout its center of symmetry. Two masses M_1 and M_2 ($M_1 > M_2$) are attached to strings which are wrapped around different parts of the winch which have radii R_1 and R_2. ($R_1 > R_2$, g is the gravitational acceleration.)

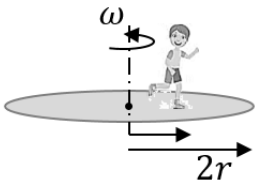


11. How are the linear acceleration a_1 and a_2 of the masses M_1 and M_2 and those with the angular acceleration α of the winch related?
(a) $\alpha = a_1/R_2 = a_2/R_1$ (b) $\alpha = a_1R_1 = a_2R_2$ (c) $\alpha = R_2/a_1 = R_1/a_2$ (d) $\alpha = a_1/R_1 = a_2/R_2$
(e) $\alpha = R_1/a_1 = R_2/a_2$

12. What is the angular acceleration α of the winch?
(a) $\alpha = g(R_2M_1 + R_1M_2)/(I + M_1{R_1}^2 + M_2{R_2}^2)$
(b) $\alpha = g(R_2M_1 - R_1M_2)/I$
(c) $\alpha = g(R_1M_1 + R_2M_2)/(I + M_1{R_1}^2 + M_2{R_2}^2)$
(d) $\alpha = g(R_1M_1 - R_2M_2)/(I + M_1{R_1}^2 + M_2{R_2}^2)$
(e) $\alpha = g(R_1M_1 - R_2M_2)/I$

13. What are the tensions T_1 and T_2 in the strings?
(a) $T_1 = M_1(g + R_1\alpha)$, $T_2 = M_2(g - R_2\alpha)$
(b) $T_1 = M_2(g - R_1\alpha)$, $T_2 = M_1(g + R_2\alpha)$
(c) $T_1 = M_1(g - R_1\alpha)$, $T_2 = M_2(g + R_2\alpha)$
(d) $T_1 = M_1(g - R_1\alpha)$, $T_2 = M_2(g - R_2\alpha)$
(e) $T_1 = M_2(g + R_1\alpha)$, $T_2 = M_1(g - R_2\alpha)$

Questions 14-18



A disc with a boy displaced a distance $r = 1$ m from the center on it, rotates around the axis of symmetry with an initial angular speed of $\omega = 6$ rad/s. The mass of the boy is $m = 12$ kg, the mass of the disc is $M = 7m$ and the radius of the disc is $R = 2r$. (The moment of inertia of a disc with mass M and radius R with respect to the axis of symmetry is $I = \frac{1}{2}MR^2$)

14. How much has the center of mass of the boy-disc system displaced along the radial direction as the boy walks straight to the rim (the edge) of the disc?
(a) $R/7$ (b) $r/4$ (c) $R/4$ (d) $r/8$ (e) $r/7$

15. The boy now stands on the rim. What is the angular speed ω in rad/s?
(a) 4 (b) 5 (c) 2/3 (d) 24/5 (e) 36/5

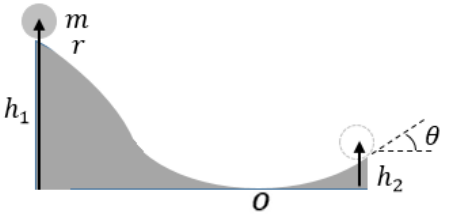
16. The boy still stands on the rim. Calculate the kinetic energy of boy-disc system.
(a) 3888 J (b) 2700 J (c) 48 J (d) 2250 J (e) 1728 J

17. A friction force 360 N is applied to the rim which causes the disc to decelerate, and eventually to stop. What is the magnitude of the angular acceleration α in rad/s^2 ?
(a) 17/3 (b) 3 (c) 4 (d) 9/2 (e) 10/3

18. What time is needed to bring the disc to stop?
(a) 3/2 s (b) 9/5 s (c) 4/3 s (d) 2 s (e) 12/5 s

Questions 19-20

A ball with mass m and radius r initially at rest rolls down the track without slipping. Moment of inertia of the ball with respect to the axis of symmetry is $I = \frac{2}{5}mr^2$. h_1 and h_2 are the heights of the center of mass with respect to point O. (assume $h = h_1 - r$, g is the gravitational acceleration)



19. What is the speed of center of mass as it arrives point O?
(a) $\sqrt{10gh/7}$ (b) $\sqrt{4gh/3}$ (c) $\sqrt{3gh}$ (d) $\sqrt{5gh/7}$ (e) $\sqrt{3gh/4}$

20. What is the maximum height with respect to height h_2 if the ball leaves the track at height h_2 with an angle θ? ($\sin\theta = 1/2$, $\cos\theta = \sqrt{3}/2$)
(a) $\frac{5}{7}(h_1 - h_2 - r)$ (b) $\frac{15}{28}(h_1 - h_2)$ (c) $\frac{5}{7}(h_1 - h_2)$ (d) $\frac{1}{4}(h_1 - h_2 + r)$ (e) $\frac{5}{28}(h_1 - h_2)$